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GRADY TRIPLETT
Editor

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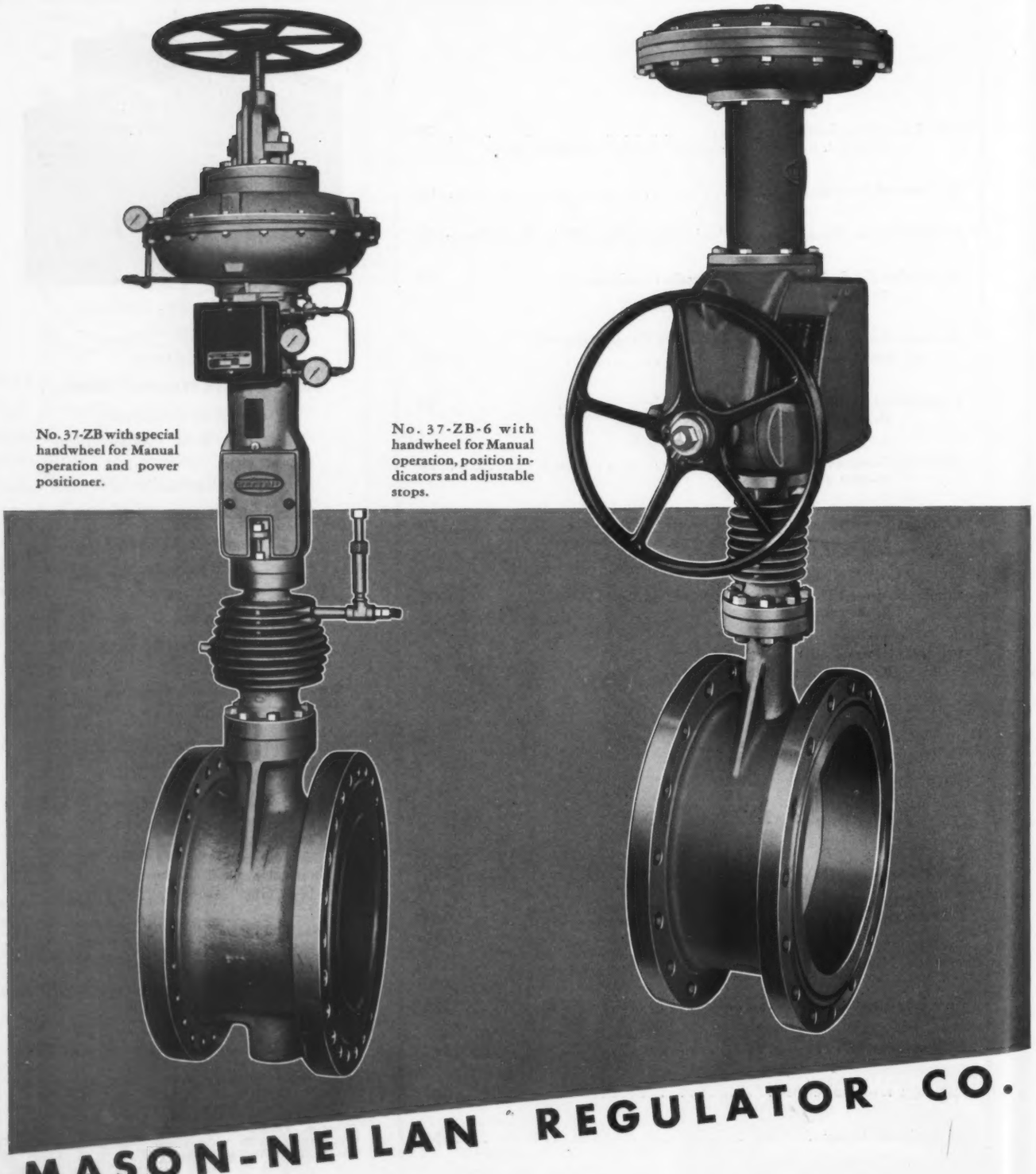
Where Plenty of Gas



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VOLUME 21, No. 2 FEBRUARY, 1942

REFINER
AND NATURAL GASOLINE MANUFACTURER

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THE LOOK BOX

WITH its goal of 150,000 barrels of 100-octane-aviation gasoline per day still to be reached, the petroleum industry now accepts the obligation of providing raw material for synthetic rubber.

Boot Strap Lifting

Curiously enough, source of part of the choice aviation fuel also is the source of raw material in the rubber program. Butanes are perhaps 20 percent of each barrel of aviation gasoline. Butanes and other hydrocarbons with four carbon atoms are the starting material for several of the processes of synthetic rubber base material.

Butanes are plentiful for the two requirements. Collecting them and separating them from other material, therefore, becomes the task. It is likely that the two products will come from common equipment in many instances. It is likely, however, that the industry will have to move backward along its line of raw materials and collect lighter hydrocarbons in many spots not now considered economical. These products are no longer waste materials in the natural-gasoline industry but there are many plants whose output is not sufficient to warrant collection. Even the natural-gas industry may be forced to process for recoverable hydrocarbons in the C_4 range.

Cost has become a secondary consideration. Rubber must be provided in quantity sufficient for the war program and it will be desirable if the amount can be pushed to a level sufficient for civilian use. Here cost is to some extent of little concern. The American economy now depends on individual transportation. As the automobile goes into disuse efficiency of American workmanship will feel the influence.

Thus oil, the source of power for individual transportation, now must provide the tires for the transportation. It is an industrial instance of lifting itself by the boot straps.

Already the industry has been called upon to pool its patents in synthetic rubber-base-stock production. The government is backing plant building to the extent of $400,000,000 with a goal of 400,000 tons of rubber the objective. Perhaps half the money total will be used by the rubber industry in processing the synthetics provided by the petroleum industry. This will leave $200,000,000 as added expenditure by the refining industry.

The 400,000 tons of rubber per year evidently is the requirement for military use and reserve. If the individual transportation problem must be met by the petroleum industry, another 400,000 tons of annual capacity is in prospect.

That is sufficient for the day. It sets the refining industry at the threshold of its most extensive plant expansion program ever contemplated for a span of two years. Given the steel, which seems assured, it will complete the job.

THE following picture of transportation handicaps in countries where gasoline no longer exists was prepared by the American Petroleum Institute:

Instead of Gasoline

"Europe's motor vehicles, the few that are still operating, are using everything from alcohol made from bakery dough to producer gas from charcoal burners to replace almost unobtainable gasoline.

"Before the war the 4,300,000 passenger cars and 1,400,000 commercial motor vehicles in Continen-

tal Europe required about 75,000,000 barrels, or more than 3,000,000,000 gallons of imported gasoline, in addition to the quantities produced at home. For more than two years these imports have been blockaded and only a few of the most essential motor vehicles can still operate.

"Four types of fuel are replacing gasoline, the Petroleum Press Bureau of London reports: liquid and gaseous products made from coal and lignite; liquid fuels obtained from oil shale and asphaltic rocks; power alcohol from farm, forestry, and other products; and producer gas generated from a variety of materials.

"German ingenuity long before the war had perfected and was operating, though with heavy government subsidy, a vast industry making petroleum from coal and lignite by two synthetic processes. Production of these high-cost fuels had reached almost to 10,000,000 barrels annually by 1938, and 1940 production may have been as high as 25,000,000 barrels. A tremendous proportion of this production of necessity is earmarked for military needs, however, and probably few civilian motorists ever see a gallon of it.

"Small additional production of liquid fuels from coal is obtained as a by-product of coal carbonization in the coke-oven and gas works industries of Germany and other European countries. Few countries besides Germany have been successful in developing a synthetic oil industry from coal, however, although France, Italy, and Belgium have made several attempts with small plants.

"Liquefied gases, mostly obtained as a by-product of Germany's coal hydrogenation plants, are being used successfully. At the end of 1939 about 40,000 German motor trucks were operating on this compressed fuel, and the number probably has increased greatly since then. The use of manufactured gas, however, has made relatively little headway.

"The second major classification of alternative motor fuels are those made from oil shale and bituminous rock. Large deposits of shale in Estonia have been operated commercially for many years, with annual production before the war of about 1,500,000 barrels. Small output is being produced at two Swedish plants, and development of deposits in unoccupied France is having an unknown, but probably only meager, success. Exploitation of asphaltic rock deposits in Italy was planned before the war, but it is believed little production has yet been achieved.

"Power alcohols are in the third category of substitute fuels, but to be used successfully they must be blended with gasoline. Peak European production of about 5,000,000 barrels was reached, it is reported, in 1936. Since the chief source of these alcohols is the food produce of farms, however, the London experts believe that current yields are much lower. In Sweden power alcohol also is made from sulfite lye, a by-product of the wood-pulp industry, and a recent news story reported small production from bakery dough.

"The fourth important type of fuel replacing gasoline is producer gas, which is generated from a wide variety of materials, including anthracite and bituminous coal, lignite, coke, peat, wood, and charcoal. These materials, of which wood and charcoal are the most suitable, are burned in gas generators to produce a combustible gas. German-occupied Europe, it is reported, has about 150,000 commercial vehicles equipped for producer gas, while Sweden has approximately 70,000.

"Use of producer gas possibly is saving Germany as much as 4,500,000 barrels of liquid motor fuel annually, The Petroleum Press Service reports. But although this may increase somewhat, there are definite limitations to its use. Adaptation to private cars is difficult. The solid fuels necessary need to be distributed over the entire area, difficult in view of Europe's already over-taxed transport system. Producer-gas vehicles suffer loss of power output, smaller carrying capacity, difficulties in hill climbing and starting, and increased engine wear. Production of suitable wood in greater quantities is almost impossible, and conversion to coal adds problems of ash disposal and further increased engine wear."

BUY BONDS

Where and How Much?

THUS far censorship requirements are that location and capacity of new aviation-gasoline, synthetic-rubber and toluol plants not be printed. While complying with this REFINER AND NATURAL GASOLINE MANUFACTURER will make further scrutiny of what in normal times might be only routine news. A publication is obligated not only to comply with requirements but also to keep its columns free of any information that the enemy might like to have.

This policy will have bearing on both the technical section of each issue as well as its departments. Locations and capacities of new plants in this issue are those about which there has been previous identical publication. There will be no further publication of such information, although it will be possible to give the news short of capacities and plant locations.

The technical pages must be kept free of some new processes which now are in commercial operation. It is known that the industry has made rapid developments in the past year. Details must be held up for the duration.

Decoking Petroleum Residues

JUDSON S. SWEARINGEN, MORRIS R. MORROW
and BRUCE JONES
Department of Chemical Engineering
The University of Texas

AT THE TIME this work was started the disposition of petroleum residues, especially cracked residues, was a problem in some sections. In others a shortage of crude oil made the conversion of residues into a suitable charging stock for cracking a desirable operation. It now appears that in the near future there will be a serious shortage of crude in many sections. For a number of years the destructive distillation of the residuum, usually called coking or decoking, has served this purpose and still appears to be the solution to it.

The first method[8] for accomplishing this was the heating of the material in a shell still or retort until all vaporizable material had distilled over and only coke remained. A shell still 10 feet in diameter would have a layer of coke about 2 feet thick in the bottom when a run was completed. In addition to the size of the equipment and the time loss due to intermittent operation this method was objectionable because of the necessity of frequent repairs to the still bottom and of the necessity of manually digging the coke out of the still.

Improvements in the process have been made both in the manner of heating the charge and in the manner of removal of the coke.

The charge can be heated[2, 10, 11] by continuous charging of the reaction chamber through a tube-still heater, the oil being allowed to stand in the reaction chamber and go to coke and distillate due to its own sensible heat. Obviously, there should be more than one chamber in parallel to allow time for cleaning out the coke. The charge may also be heated by contact

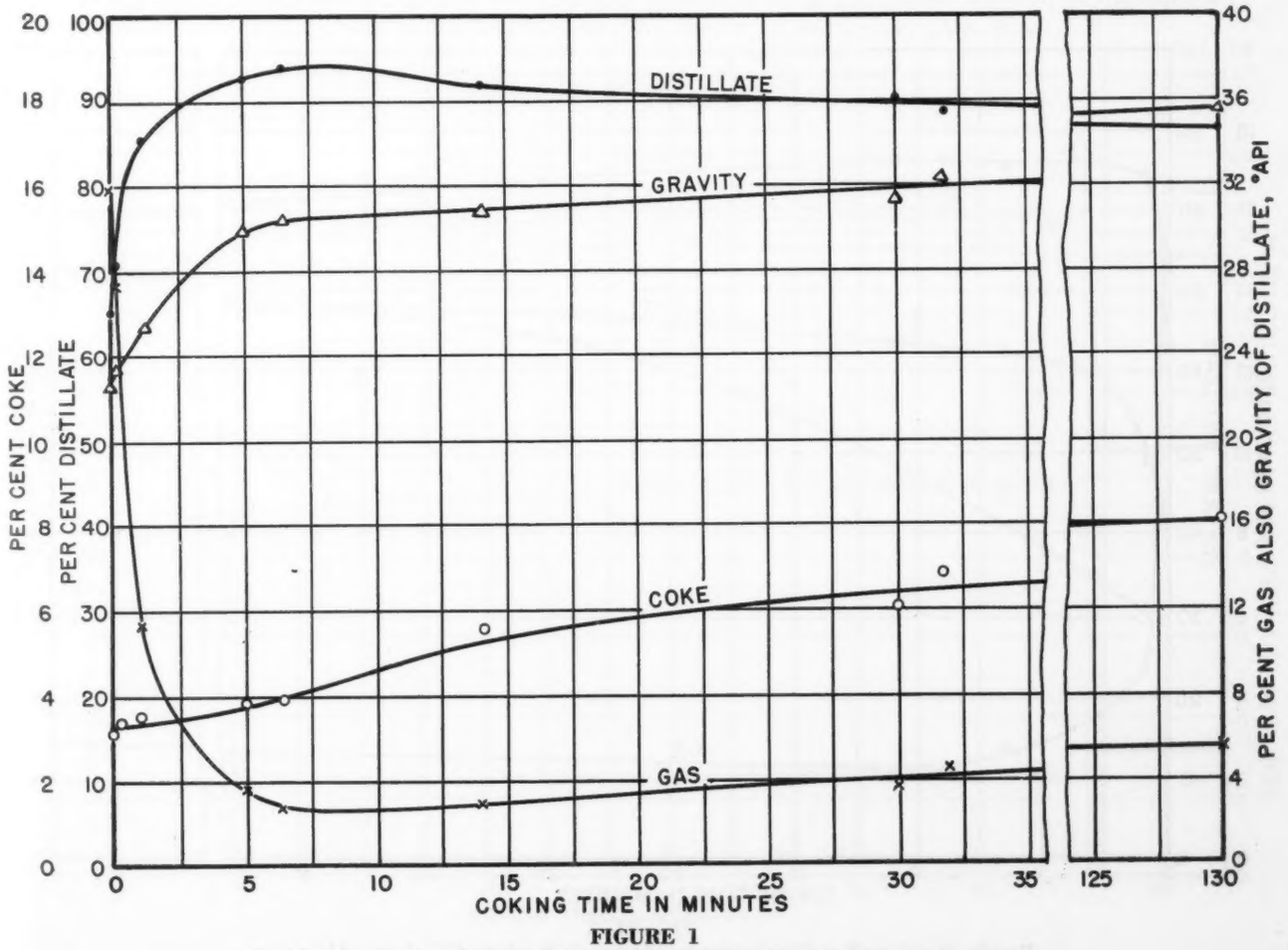

FIGURE 1
Results from small coking apparatus for stock A, plotted against coking time.

with a hot stream in the cracking unit where the two enter the reaction chamber together. Variations of these methods with even the inclusion of recirculation of a portion of the residuum are possible and necessary to suit particular conditions.

These methods of heating are particularly feasible in view of the fact that the residuum is available in a continuous stream at about 850° F. The development of these methods was apparently delayed until cracking plant control was perfected and made sufficiently automatic that additional continuous apparatus also requiring control could be attached without unduly complicating and hampering the whole operation.

The methods of coke removal have also been improved with three methods predominating, namely cable pulling, drilling, and the hydraulic method.

The cable pulling method consists of filling the coke chamber with layers of steel cable in spirals. When the chamber has been filled with coke the removal of the cable by means of a winch located on the end of the drum plows up the coke so that it practically falls out. The disadvantages are the labor requirement, the presence of wire in the coke and the time required (8-15 hours or longer).

The drilling method is, as the name implies, the removal of the coke by a series of drilling operations.

The hydraulic method[1] involves the use of high pressure (1,200 pounds per square inch) jets of water which literally wash the coke out of the drum. The relative merits of these methods are compared by Watson[11].

Two special methods for coking petroleum residues are described by Jones[4, 5, 6] and Foster[3] respectively. Jones carried out the coking reaction in a continuous chain of buckets passing through an oven. Foster[3] describes the Knowles oven wherein the oil is charged to the floor of the oven in batches, described also by Staley[9]. The operation is quite similar to that of coke ovens. One purpose of this apparatus is the production of a harder grade of coke. The distillate also contains a considerable amount of aromatics.

The properties of petroleum coke and the control of these properties is discussed by Watson[10, 11] who also gives the overall plant yields with and without coking. Morrell and Egloff[7] give the average density of petroleum coke as it comes from the coke drum.

A study of the effects of coking conditions and of the type of residuum on the yields of products and on the properties of the liquid product is apparently not recorded anywhere in the literature and so constitutes an important part of the present work wherein the effect of temperature and period of detention and the type of charging stock were varied. In the light of these data a method and a large laboratory apparatus for carrying out the reaction under optimum conditions is described and the results given.

The apparatus for the study of coking conditions consisted of a 400 cc. iron retort with thermocouple well extending to within ¾ inch of the bottom, vapor connection, and a feed pipe such that the feed falls from the feed pipe directly to the bottom of the vessel wihout running along the walls. The condenser was in two parts in series, the first part condensing and collecting the paraffin and the second part condensing the remaining vapors. A constriction con-

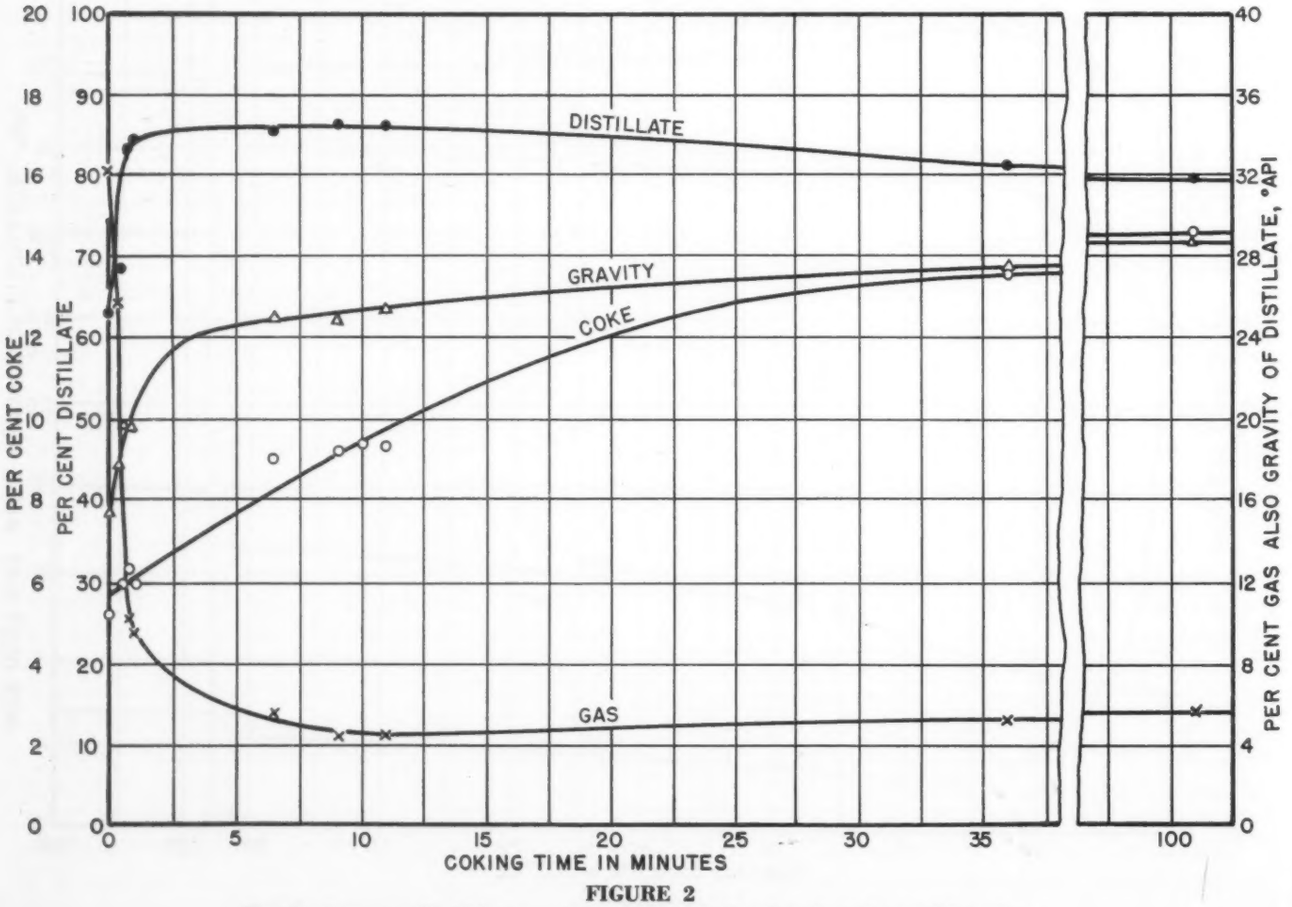

FIGURE 2

Results from small coking apparatus for stock B, plotted against coking time.

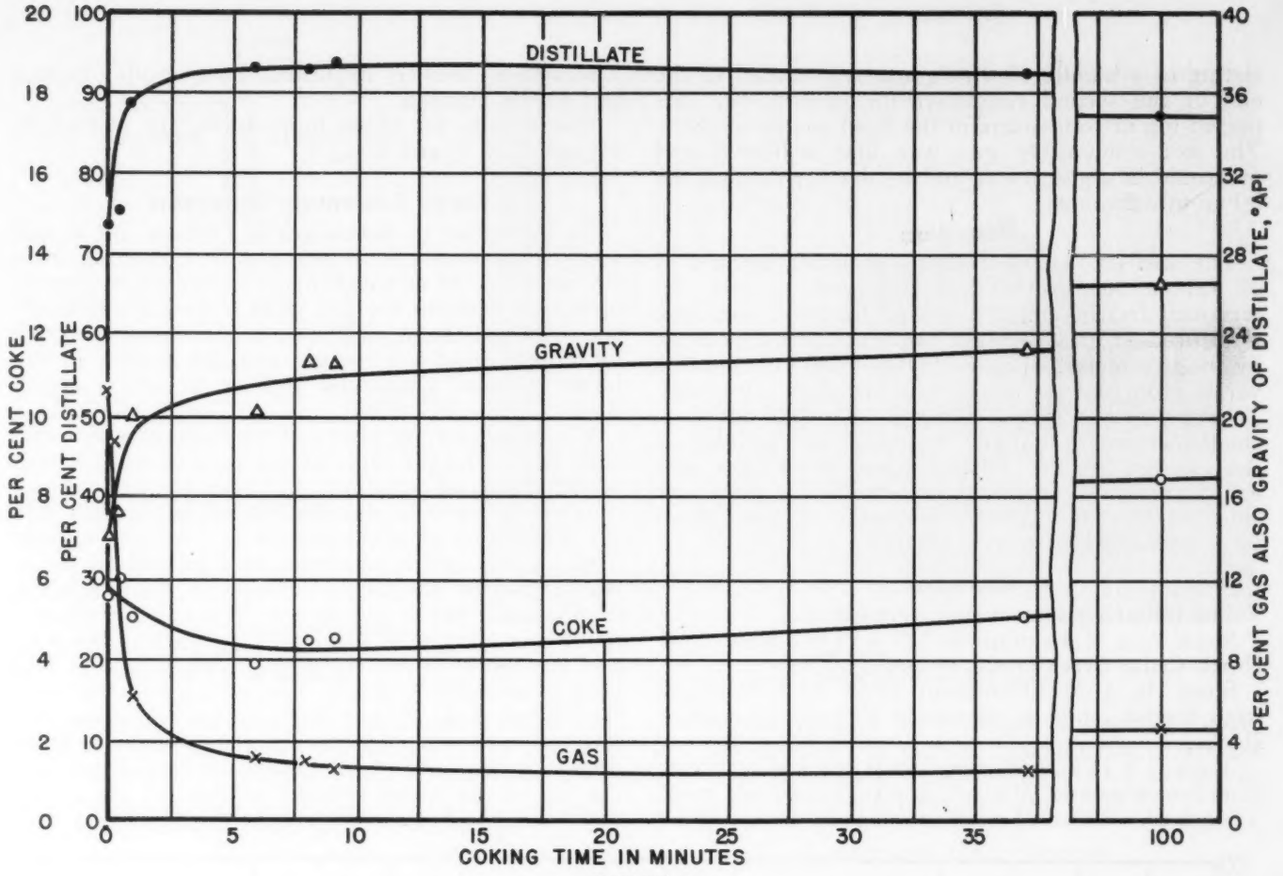

FIGURE 3
Results from small coking apparatus for stock C, plotted against coking time.

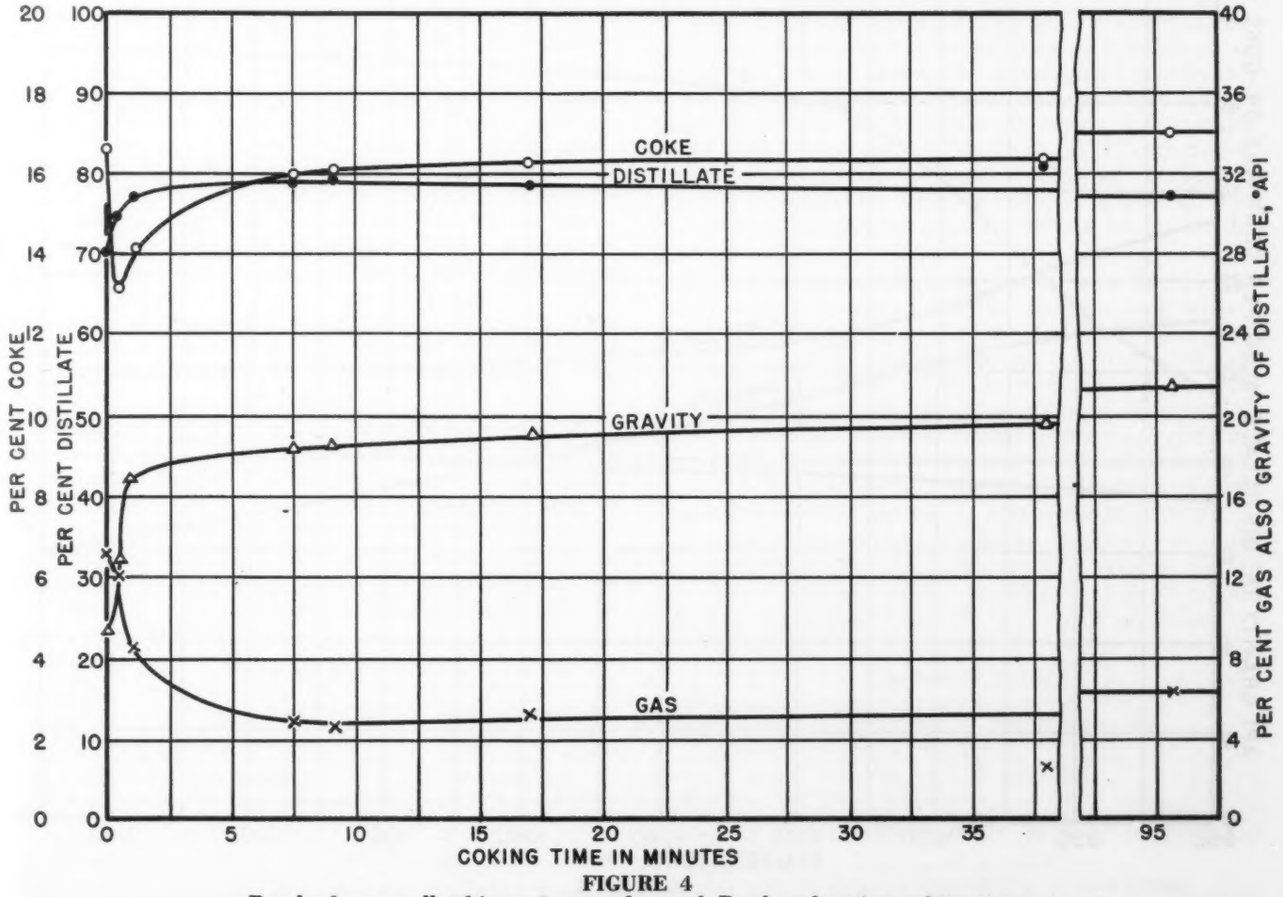

FIGURE 4
Results from small coking apparatus for stock D, plotted against coking time.

sisting of a bundle of wire gauze was placed in the end of the second condenser for causing the dispersed fog of condensate in the fixed gas to coalesce. The non-condensible gas was also collected and measured in a gasometer and its density determined by an effusiometer.

Procedure

The still was charged with a weighed amount of oil (about 100 grams) and the reaction time determined by the time necessary to distill over the total product at a constant temperature as recorded by the pyrometer. The time by this method could be varied from several hours down to 6 or 8 minutes. To get shorter reaction times the oil was added in small increments and the reaction time recorded as the average of the times during which gas was evolved after each increment of charge. To get a very short reaction time the oil was added dropwise and the time estimated at 0.01 minute.

Materials

The following four stocks were studied:

Stock A, a Mid-Continent 23° API residuum from North Cedar Creek crude, topped only.

Stock B, a Mid-Continent 18.5° API residuum from Taylor crude, a mixture of topped and cracked stocks.

Stock C, a 14.5° API mixed-base cracked residuum from Somerset and Whitsett crudes, a cut-back stock.

Stock D, a 7.8° API cracked residuum from a West Texas-New Mexico naphthinic-base crude, topped and deeply cracked.

The results for these four stocks are plotted in Figures 1, 2, 3, and 4.

Large Laboratory Apparatus

By inspection of the curves in Figures 1, 2, 3, and 4 it is seen that a short reaction time ranging from 0.5 minute to 10 minutes there is a favorable zone of operation wherein the gas yield is near a minimum, the overhead liquid yield near a maximum, the coke yield near or at a minimum and the gravity of the liquid product almost as high as at any reaction time.

This suggests carrying out the coking reaction in thin films. The principle of the method used herein is the continual addition of charge through a feed pipe in the top of an externally-fired vessel such that the oil falls on an accumulation of coke on the floor of the vessel and is converted to coke and vapor on the surface of the coke accumulation, thus building up the coke like a stalagmite. If it is built upon a loose layer of coke or soil it will not stick to the floor and can be removed by simply removing the still bottom and lifting it off. The atmosphere between the heated walls of the vessel and the oil on the surface of the coke must be transparent and this is facilitated by the addition of a small stream of gas into the top of the vessel and the removal of the heavy vapors at the bottom. The coke deposit has a ten-

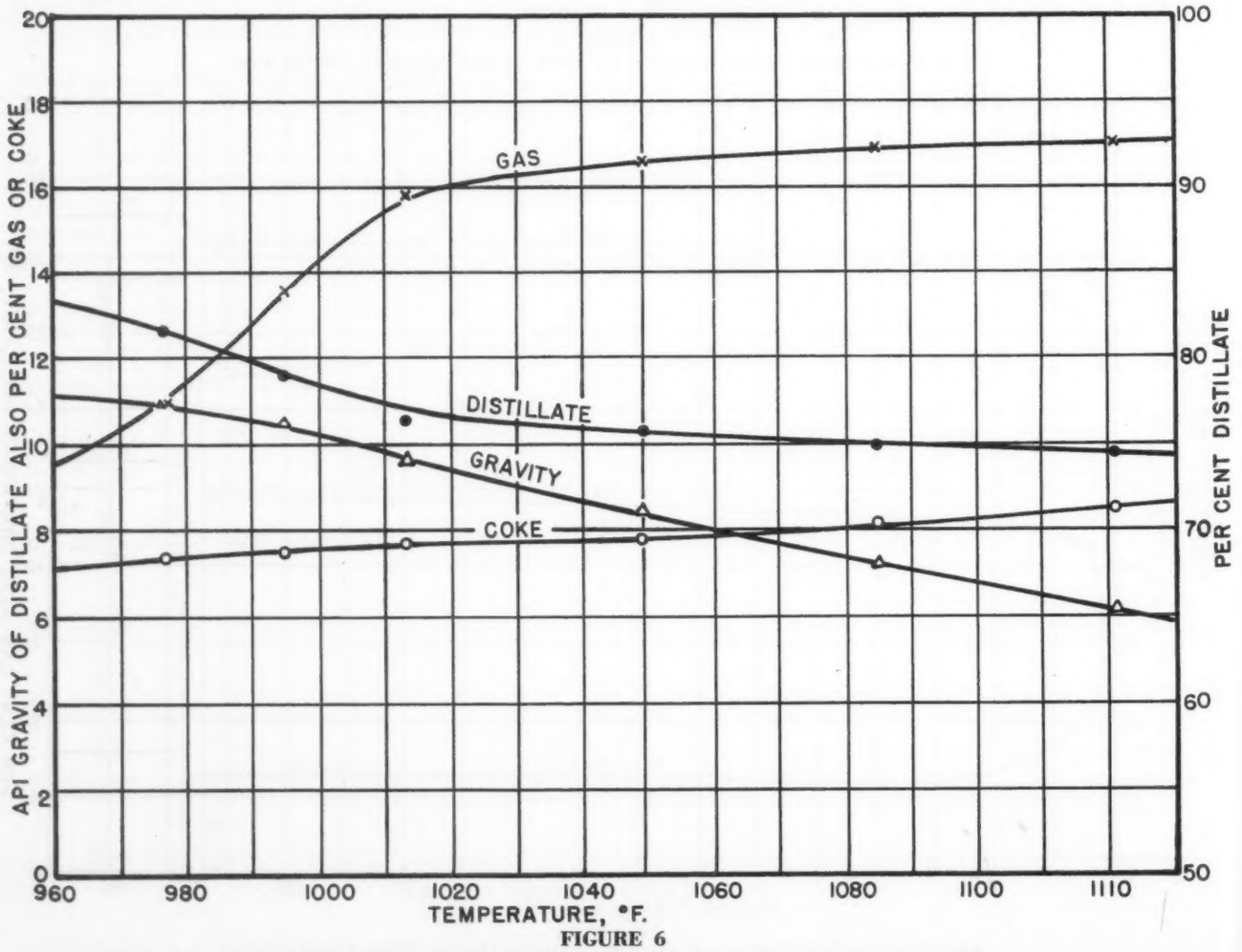

FIGURE 6

Results from large coking apparatus for stock D, plotted against temperature as recorded on pyrometer.

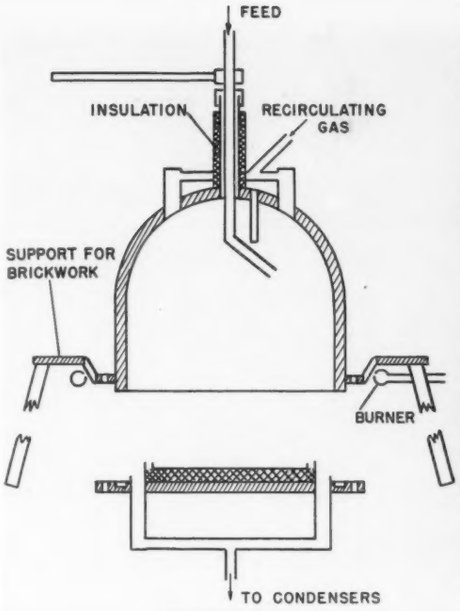

FIGURE 5
Large coking apparatus.

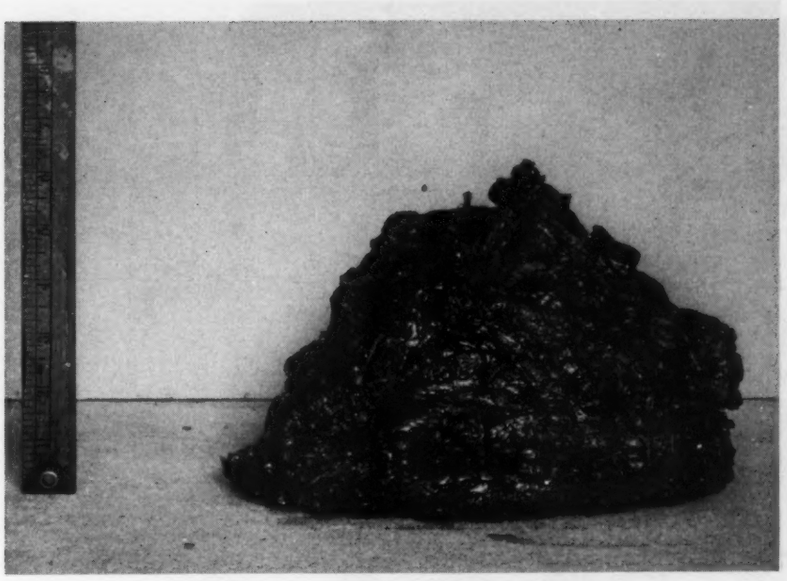

FIGURE 7
Coke "stalagmite" from large coking apparatus.

dency to maintain established channels through it or along its sides and this necessitated at least in this small apparatus a feed pipe whose position was being continually changed to allow time for these passages and spillways to be plugged by coke formation.

The apparatus that was built and tested consisted of a dome-shaped vessel 16 inches in diameter with removable bottom as shown in Figure 5. The dome-shaped part was enclosed in brickwork and heat applied by the gas burner.

Results obtained with this apparatus are limited to the low gravity stock D. As seen by comparison of Figures 1, 2, 3, and 4, this stock gives the highest carbon and gas yields and the lowest gravity product and hence subjects the apparatus to the most severe tests that could be made. The results are shown in Figure 6. These curves are plotted against shell wall temperature as contrasted to the curves in Figures 1, 2, 3, and 4 which are plotted against reaction times. The points on the curves in Figure 6 are for 500-gram charges except for the point at 995° F. which is for a run of 8.2 gallons of oil. This run built the coke up until it touched the rather low feed pipe. A photograph of the coke deposit from this long run is shown in Figure 7.

The overhead product was charged to a laboratory cracking unit especially designed for duplicating plant-scale results. The octane number of the gasoline thus produced was 6 points higher than that of the gasoline from cracking the original crude. It is also pointed out that the material was difficult to crack. It permitted only about half as much cracking per pass as average charging stocks but about the same as aromatic stocks.

TABLE 1

Distillate		
Viscosity at 100° F.	59.6 Saybolt Sec.	
Viscosity at 130° F.	49.0 Saybolt Sec.	
Viscosity at 210° F.	35.1 Saybolt Sec.	
Conradson Carbon Residue	3.94 percent	
Octane Number of cracked gasoline	75	(L-3 method)
Octane Number of refinery cracked gasoline (where residuum was produced	69	(L-3 method)
Coke		
Apparent density of coke	51.0 lb./cu. ft.	

The properties of the overhead product, the coke, and the gasoline formed by cracking the overhead product (which gasoline includes gasoline already in the overhead product) are listed in Table 1.

Commercial Unit Capacity

Coking took place only on top of the coke stalagmite. Estimating from the area of the top of this coke deposit, an apparatus producing a coke deposit 9 feet in diameter would have a capacity of 100 barrels per day. The oil apparently stood in small puddles and the actual area involved may have been considerably less thereby giving the above projected unit a daily capacity substantially higher than this if a suitable spray nozzle were used to feed the oil. The charge to the laboratory still was not preheated except by passing through the short feed pipe. If hot oil were charged to the unit its capacity should be further increased.

The apparatus could consist of a brick-lined cylindrical vessel insulated on the outside and with a dome-or cone-shaped top of heat-resisting alloy exposed to a radiant heater wherein the heat is all supplied through the top. The bottom should be a removable plate of any of several suitable types. A layer of coke fines or soil would prevent overheating the bottom at the beginning and would also allow removal of the coke deposit by simply lifting it off. The apparatus would operate at atmospheric pressure.

Since the removal of the coke is a matter of minutes and the initial cost not excessive this type of coking apparatus appears to be feasible for small plants where a few hundred barrels per day of residuum are to be processed.

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IN CASE OF BOMBING

Daily practice within the shelter includes some first aid routine under the supervision of the company doctor. The 6-inch pipe supports are filled with cement.

SAND-BAG protection for the Signal Hill refining plant of Macmillan Petroleum Corporation, Los Angeles, was started the day after the Pearl Harbor incident. The work had the supervision of military authorities, who also approved release of details for the benefit of the refining industry.

Sand bags around all buildings, tanks and process equipment was but part of the precaution against air raids. The plant will have five bomb shelters, each capable of protecting 30 persons. There will be a nurse for each. Each building will have both electric and emergency lights, food, water, first aid equipment, tools such as picks, shovels, drills and jack hammers.

Some of the details of placing sand bags, bomb proof shelter protection and drills are shown on this and the following page.

An Army officer directs refinery workmen in details of building sand bag protection for equipment. Bags should be three-fourths full and staggered double. The width is 24 inches. Bomb fragments, exploding 20 feet away, would not penetrate this defense. William Powell, plant superintendent, looks on from the right.

Before the first bomb shelter was completed, practice alarms were started. The best time for these early drills was 25 seconds from sounding of the alarm until the last man was inside the shelter. Later 12 inches of sand was placed on the shelter roof and the layer of filled bags placed on this. This is calculated to detonate a bomb before it contacts the shelter proper. The ventilator serves as an emergency exit.

Cabot Carbon Company

Sub-Cools Absorption Oil in Two Phases

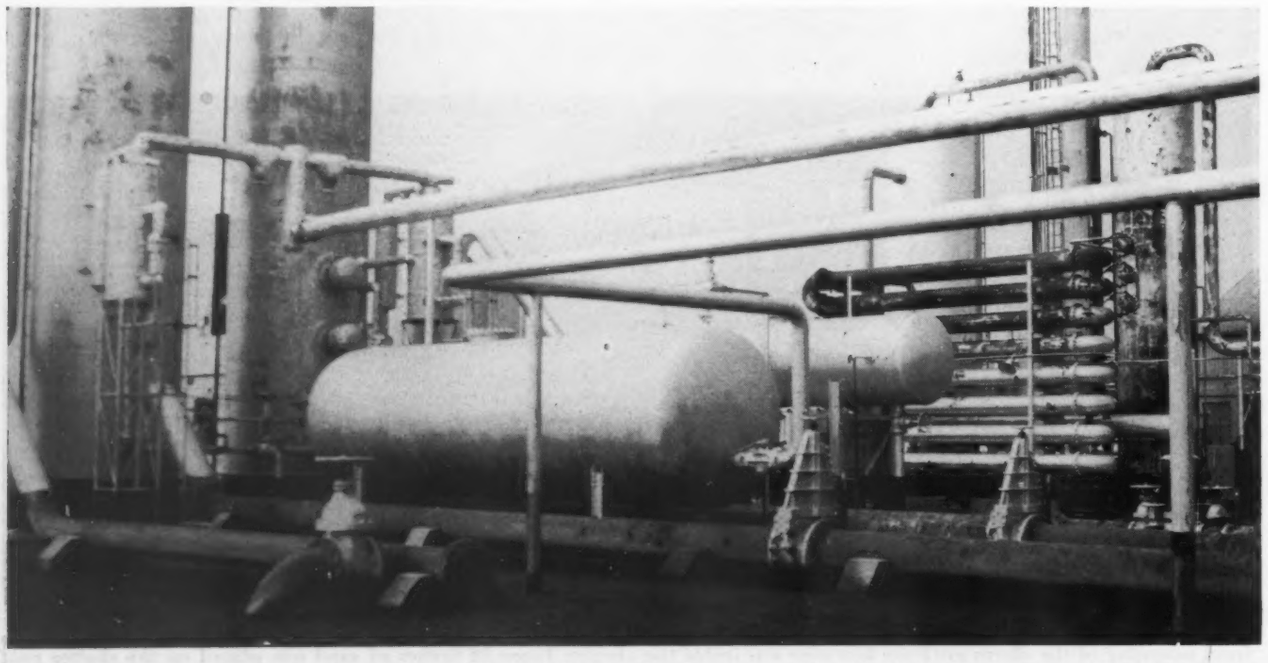
CABOT Carbon Company applies artificial cooling to the absorption oil in its Estes gasoline plant, Ward County, Texas, in two phases. The principal application of chilling is in the base of the absorbers, while the secondary application is after the absorption oil has passed through the atmospheric sections in the cooling tower. Since the greatest rise in temperature in the absorbers is at the first contact between the gas and the oil, these absorbers are equipped with two tube bundles each, located immediately above the connection through which the compressed gas enters the columns. The oil which is chilled in the second phase enters the top of the absorbers above the bubble trays at a temperature sufficiently low to absorb and retain propane and heavier fractions extracted in the absorption process.

In this plant approximately 3,500,000 cubic feet of fractionated butane vapors are compressed daily to liquified products for maintaining the desired temperatures in the absorbers and on the lean oil from the atmospheric coolers. A 300-horsepower gas-engine-driven compressor takes suction on the vaporized butane at an average pressure of 3 inches Hg vacuum, and compresses the load to 70 psi, with the compressed butane passing through four banks of 19-foot atmospheric coolers. A butane receiver sits between the cooling tower and the absorbers as a reserve for liquified butane.

Two hair-pin type tube bundles are located, one above the other in each absorber with the heads facing the reserve tank, and piped with each other in series to the liquid flow of butane. Each pair of internal chillers is equipped with a separate volume tank having a liquid-level controller to maintain the required level of butane for obtaining flooded operation. With this arrangement, the liquid butane flows from the reserve surge tank to both absorbers in parallel, with the vapors collected in a line common to both sets of chillers and led to the absorption oil cooler near the water-cooling tower.

The drop in temperature of the oil and gas in the base of the absorbers is controlled by gate valves in the vapor lines from the hair-pin chillers, which are set to place the necessary back pressure on the butane to accelerate or reduce the rate of vaporization of the butane. The line carrying the butane vapors from the absorber chillers is insulated to prevent loss of refrigeration before reaching the butane vapor to absorption-oil cooler.

The vapor-to-absorption-oil cooler is made in the plant shops from a 40-foot section of 24-inch pipe, with 212 ½-inch tubes inside and connected for oil flow through the tubes and butane in the shell. Since most of the butane is expanded to vapor in the two pair of hair-pin bundles in the absorbers, the material entering the vapor-to-oil exchanger is a



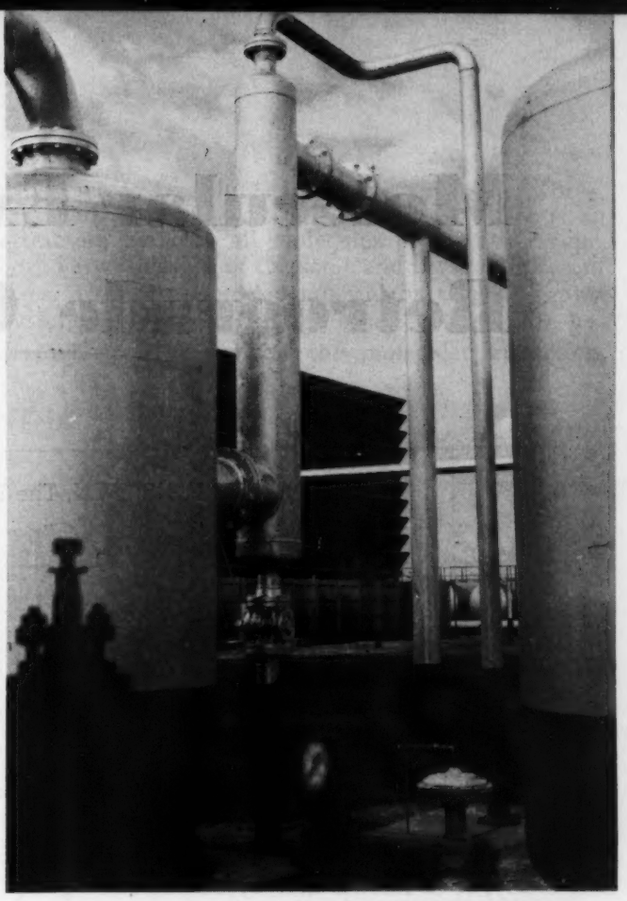
A common surge tank supplies butane for chilling in the two absorber columns, each of which is equipped with two inset cooling sections.

mixture of vapors and liquid, which is reduced in pressure with a pilot-operated controller at the entrance to the exchanger. The piping is arranged so that the refrigerant enters the exchanger at the base and passes to the suction line of the compressor at opposite end through a top connection. With the reduced pressure in the shell of the exchanger and the direction of flow, a combination of flooded—at one end—and vapor chilling is obtained, sufficient to reduce the temperature of the oil from summer conditions of 92°F. in, and 80°F. out.

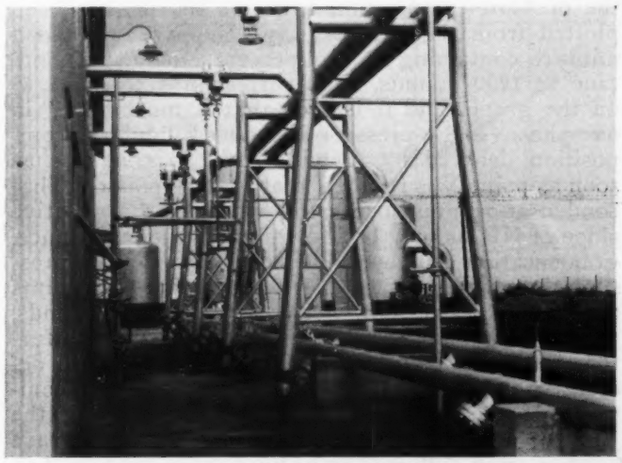
With an oil temperature at the inlet of the absorbers above the top bubble tray running around 80°F. during summer, desired fractions are prevented from passing to the residue line in the stripped gas, and by controlling the temperature of the oil and gas in the base of the columns, fractions are retained in the oil as it leaves the columns to obtain the necessary composition of the raw gasoline for manufacturing any grade of natural gasoline and liquified petroleum gases.

To prevent the possibility of liquid butane from entering the scrubber on the inlet to the compressor cylinders of the angle type machine, a thermostat controlled vapor heater is installed in the vapor line near the inlet connection of the scrubber. If a quantity of butane vapors mixed with liquid should leave the vapor to absorption-oil exchanger at a temperature low enough to prevent complete vaporization of the liquid butane, the controller on the vaporizer at the scrubber opens a valve to pass steam into the apparatus so that the temperature is raised sufficiently high to insure complete vaporization of any butane liquid at that point.

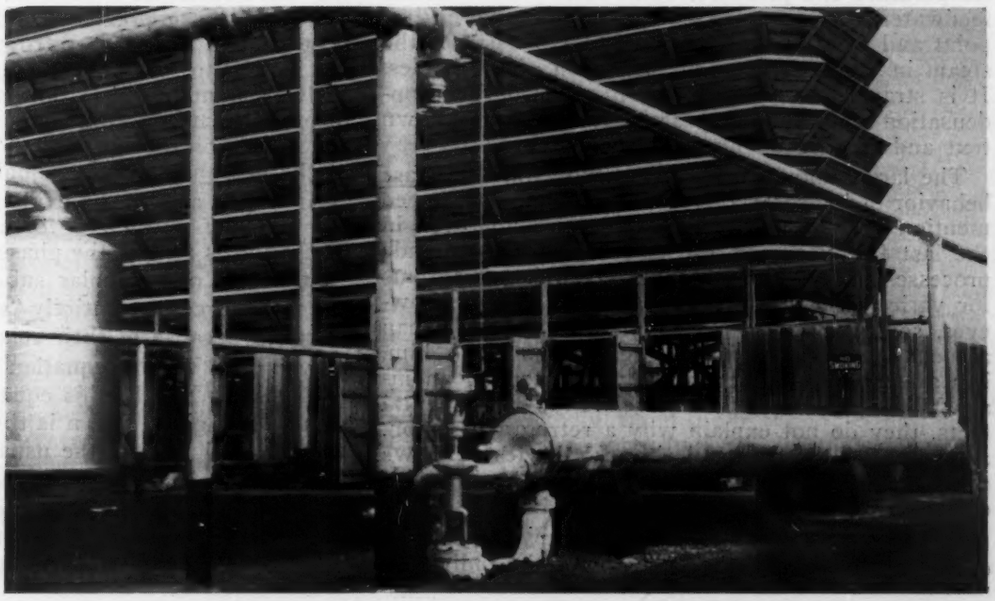
The suction and discharge piping to and from the compressors are installed on concrete piers and high steel supports outside the engine room with control valves in the open so that any gas which might escape through valve stem packing will be dissipated in the air instead of collecting in the building.



Intake and discharge headers on the butane circuit are elevated, with gate valve bonnets turned downward and equipped with extension handles.



An automatic heater on the butane vapor line between the chillers and scrubber maintains sufficient heat to prevent liquid from entering the vessel.



Second phase in absorption oil cooling is in a plant fabricated unit into whose tube sections the oil enters for cooling with butane liquid and vapors. Average reduction is from 92° F. to 80° F., at which the absorbing medium enters the absorbers.

Molecular Explanation of Retrograde Condensation

RALPH F. NIELSEN, The Pennsylvania State College

THE phenomena of retrograde condensation and its reverse, retrograde vaporization, are now well known to the petroleum production engineer. The fact that liquid may be produced by isothermal expansion of a multicomponent gas mixture at high pressure is known from the study of the behavior of the mixture produced from a "condensate" field. Conversely, it is known that by recompressing the same mixture (isothermally) the liquid phase is made to disappear into the gas phase. The related phenomena, isobaric retrograde condensation and vaporization (by raising and lowering the temperature, respectively, at constant pressure) are not of any immediate importance in production practice.

While these retrograde processes have only recently come into importance in petroleum production, they have been known for about 50 years. The process was observed and named "retrograde condensation" by Kuenen[1] in 1893. It was also predicted from van der Waals' theory for binary mixtures.[2] Physical chemists have since studied many binary mixtures in the critical range, including the range in which retrograde condensation occurs. Steam engineers were confronted with the phenomenon some 15 years ago in connection with the Benson boiler, designed to operate with steam above the critical temperature and pressure. Some salts present in the feedwater remained in solution above the critical point and were precipitated during expansion of the steam in the turbine, causing erosion of the blades. It is strange that even mention of retrograde condensation is absent from practically every well known text and treatise on physical chemistry.

The large amount of excellent work on the phase behavior of hydrocarbons is too well known to need mention here. Many articles have also appeared in the last few years on the discussion of retrograde processes as related to the phase boundary diagrams for various mixtures. To the average person, however, some kind of physical picture, which he can associate with phenomena already known to him, is a great help in understanding this seeming anomaly. While phase diagrams correlate the experimental facts, they do not explain why a retrograde region, as shown by the curves, is in accord with what we otherwise know or assume regarding the behavior of matter.

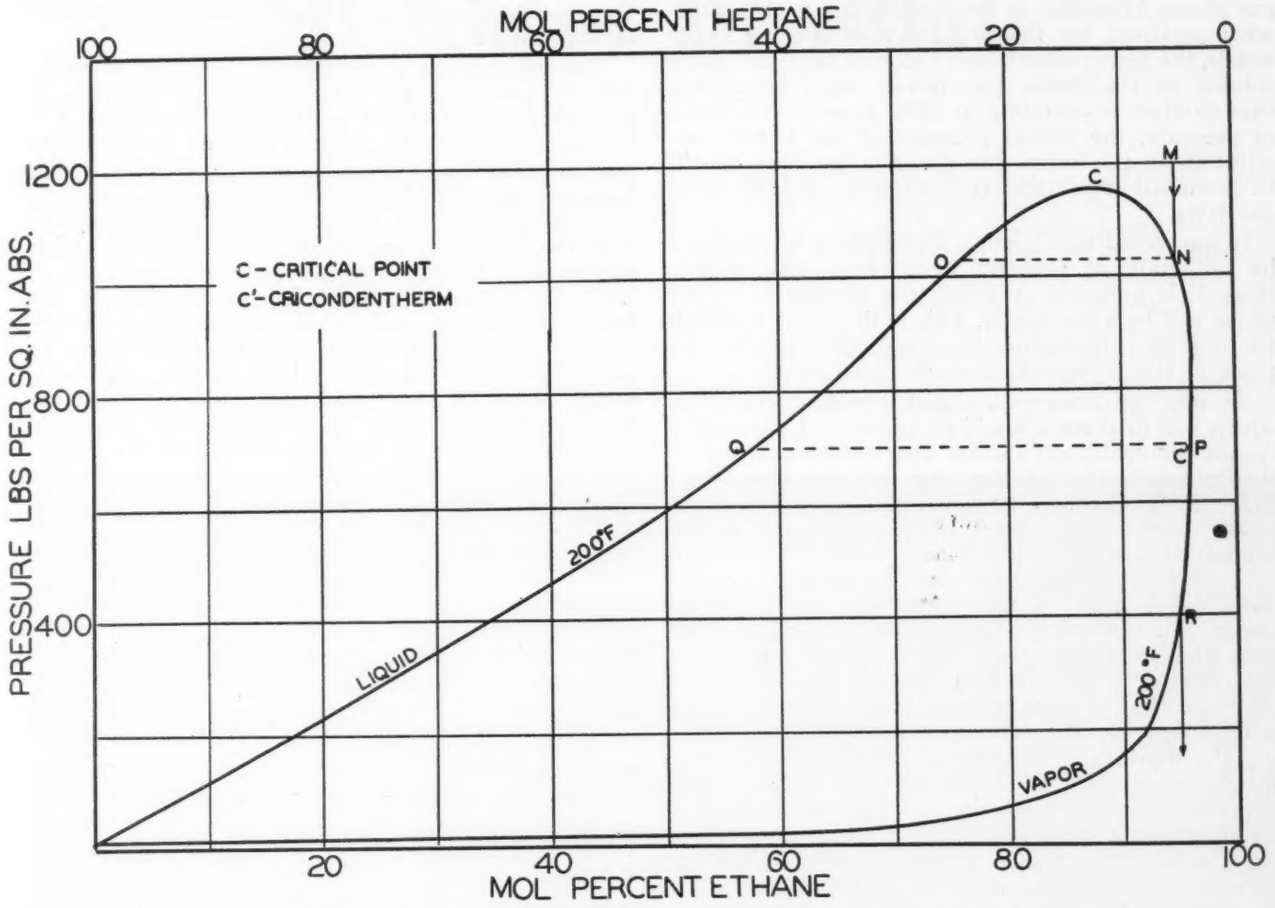
The most logical way of picturing why the process occurs is to consider the behavior of the individual molecules. It is conceded as a fact that there are certain attractive forces between molecules. The molecular explanation of retrograde condensation is based on such forces.

Before proceeding with the theory, let us briefly review the facts for a two-component case, the ethane-heptane system. In the accompanying graph, the pressure-composition curve at 200° F. has been plotted from the data of Kay.[3] Suppose we had a mixture containing 95 mol-percent ethane and heptane at 1200 pounds. This corresponds to point M on the graph, and it is seen that it must be all in one phase. If the pressure is reduced, liquid of composition denoted by O will begin to condense as soon as point N is reached, that is, 1030 pounds. That condensation must occur follows from the negative slope of NP, as may be shown by a material balance. Condensation will continue with reduction of pressure, the compositions following corresponding points along the curves, until P is reached at 700 pounds, when the amount of liquid is a maximum. With further reduction of pressure the amount of liquid decreases, at 400 pounds, point R, evaporation is complete. If the pressure is still further reduced, the vapor simply expands. Thus, we have retrograde condensation, followed by ordinary vaporization, during the isothermal expansion. If the expanded mixture were recompressed, condensation would occur up to 700 pounds, then retrograde vaporization from 700 pounds to 1030 pounds. That is, from 700 pounds to 1030 pounds vaporization is produced by increase of pressure at constant temperature. A material balance based on the curve would show that 26 percent of the heptane is in the liquid phase at 700 pounds.

As stated above, the explanation involves the assumption of attractive forces between molecules. These forces govern the phase behavior of a system. In the case of non-polar substances, like hydrocarbons, the forces are entirely "van der Waals' forces," so-called because of their relation to the term a/V^2 in van der Waals' equation of state, $(P + a/V^2)(V - b) = nRT$. In this equation, a and b are constants for a given gas, n is the number of mols, and P, V, R and T have the usual significance.

Although van der Waals' equation does not hold quantitatively at high pressures, it presents a simple explanation of the behavior of a gas. The term b is subtracted from the volume to allow for the space

occupied by the molecules themselves. That is, V — b is the net space available for molecular motion. The term $\underline{a}/V^2$ is often called the "internal pressure," since it is a correction applied to the pressure due to the attraction between molecules. It is added to the pressure, since attraction between molecules acts in the same way as external pressure, to reduce the volume. While $\underline{a}/V^2$ measures the effect on the total pressure, $\underline{a}$ is a measure of the attraction of the individual molecules for each other at a given distance apart.



Pressure-composition curve at 200° F. for the ethane-n-heptane system, from the data of Kay[1]

It is these forces which make a liquid surface act like an elastic membrane, on account of the one-sided attraction on the molecules in the surface. While the "van der Waals' forces" tend to pull molecules together into the liquid state, the molecular motion (kinetic energy) associated with a given temperature tends to pull them apart. Under conditions where liquid and vapor can co-exist, these opposing factors are balanced so that part of the substance is in each phase. When the temperature is above the critical, the attractive forces cannot maintain a liquid phase on account of the higher kinetic energies associated with the higher temperature. At pressures below the vapor pressure of the liquid, the attractive forces become lessened by the greater distance between molecules, so the liquid phase again cannot exist.

It is these same attractive forces that cause one substance to be soluble in another; in other words, that pull molecules into a given phase. There is an attraction between all molecules of a similar type, both between those of the same and those of different sizes. The attraction depends on the size, as shown by tables of values for $\underline{a}$ for a series of paraffin hydrocarbons. The smaller the molecular attraction, the more volatile the substance. This is shown by the following table of van der Waals' $\underline{a}$, for pressure in atmospheres and V = 1 at 0° C. and one atmosphere:

Gas	$\underline{a}$
Methane	.0045
Ethane	.0107
Propane	.017
n-Butane	.029
n-Pentane	.038
n-Hexane	.049

While the normal processes of vaporization and condensation are associated relatively more with the attraction of the heavier molecules for each other, the retrograde processes are associated with the attraction between the light and the heavy molecules. The former type of attraction tends to pull molecules into the liquid phase and the latter to pull the heavier molecules into the gaseous phase, when the gaseous phase is sufficiently dense. Consider the reverse of the process previously described for a mixture of ethane and heptane. If we start with all gas at a low

pressure, and increase the pressure at 200°, liquid will begin to form at 400 pounds. At this point, the molecules are close enough together so that the larger attractive forces between the heavier molecules become operative and form a liquid phase. Above 700 pounds the smaller forces exerted by the light molecules remaining in the gas phase become more effective, due to the greater proximity of the molecules, so that the heavier molecules are attracted into the gas phase. Attraction in the liquid phase is also somewhat lessened by the dissolved ethane. In other words, the heavy constituent becomes more and more soluble in the dense gas phase, until retrograde vaporization is complete at 1030 pounds. In terms of pressure, the partial pressure of the heavy constituents in the dense gas phase is less than would be predicted from their concentration and the ideal gas laws.

It was noted that when a liquid phase is produced by reduction of pressure at contant temperature, there is a pressure at which the volume of liquid phase will be a maximum. This is the point at which the normal vaporization process begins to take the place of the retrograde condensation process.

Suppose we start wtih a high-pressure gas phase which will produce a liquid on isothermal expansion. As the molecules get further apart, the attraction of the light molecules for the heavy becomes less. Thus, the heavy molecules cannot be held in the vapor phase by the light molecules in opposition to the mutual attraction of the heavy molecules for each other, this latter attraction causing the heavy molecules (with some of the lighter) to form a liquid phase. The amount of liquid increases for a time as attraction in the gas phase decreases, but meanwhile evaporation by the normal process becomes more effective. The normal process is as follows: If the volume is increased, the number of molecules striking the liquid surface from the vapor becomes less for an instant, so that the number leaving the liquid exceeds the number entering, until a new balance is obtained with less liquid. This normal vaporization process becomes effective at pressures below that of maximum condensate. In simple language, the retrograde processes may be regarded as solution processes in the gaseous phase, the solubility of heavy constituents in the gas phase increasing with the amount of compression.

In the case of the complex hydrocarbon mixtures encountered in "condensate" reservoirs, the phase behavior is similar to that of the two-component system discussed, even if the complex mixture cannot be completely represented on a quantitative basis. Since the critical point (both temperature and pressure) is definitely established for a given composition, it is not likely that the mixture is at the critical point in the reservoir. Most likely it is a gas outside the two-phase region, or it is a gas in equilibrium with a liquid phase which is not produced from the well. This liquid phase may be a crude, even though the gas phase will yield a high gravity "condensate" on expansion.

The explanation of retrograde behavior is qualitatively the same for multicomponent mixtures as for the two-component system just discussed. For instance, suppose the gaseous mixture in the reservoir is at 4000 pounds pressure and 180° F. At this high pressure the light molecules, which make up most of the mixture, are close enough together to hold the heavier molecules in the gaseous phase. If the pressure is reduced at a constant temperature of 180°, the attraction of the light molecules for the heavy is lessened, and liquid condenses out. Retrograde condensation would probably occur down to about 1000 pounds, after which further expansion would result in a decrease in the amount of liquid by normal vaporization. In actual practice, of course, the temperature also drops as a result of the expansion, hence one could not be sure from such data alone that the condensation was not due merely to the temperature drop. However, it is well known from other observations, and from testing apparatus, that condensation will take place during isothermal expansion of such a "condensate" reservoir mixture. At lower temperatures the amount of retrograde condensation is much greater. If the reservoir mixture were cooled to, say, 40°, and then expanded isothermally, by far the greater part of the condensation would take place during the expansion, the total condensate being several times that produced at 180°. The amounts of condensate at various temperatures and pressures can of course be calculated approximately by the well known method of "equilibrium constants," combined with a knowledge of the composition of the mixture through hexanes or heptanes, adjusting "K" for the heavier constituents so that the calculated and experimental dew points agree.

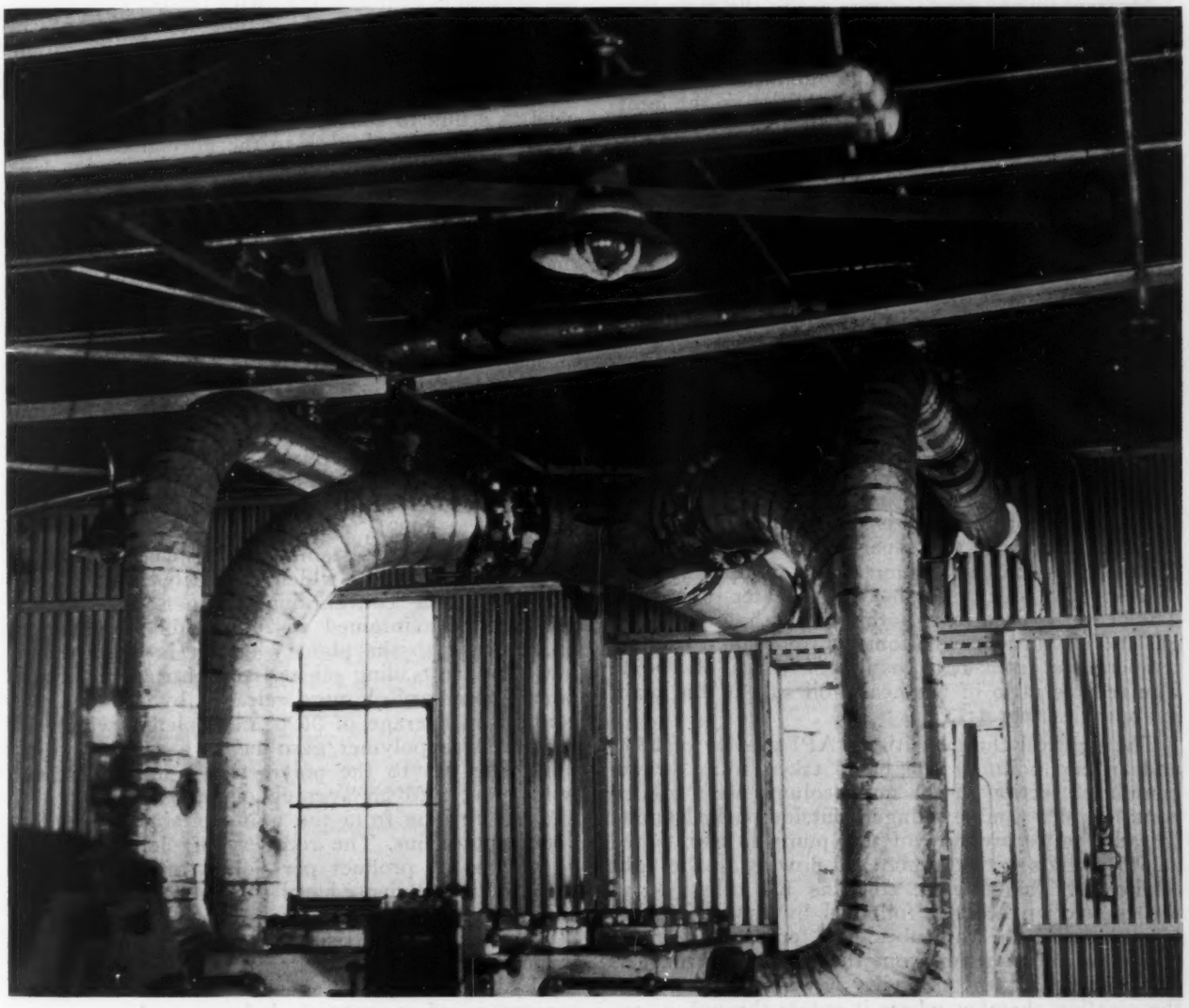
REFERENCES

[1] Kuenen, Zeit. physik, Chem., vol. 11, p 38 (1893).
[2] van der Waals, Zeit. physik, Chem., vol. 5, pp 133-173 (1890).
[3] Kay, Ind. Eng. Chem., vol. 30, p 459 (1938).

Revised Cracking Technique Increases Octane Rating of Michigan Distillate

WHILE Michigan crude oil long has been known to possess excellent qualities for the manufacture of technical naphthas, early cracking was unsatisfactory from a standpoint of high-octane production. Refiners attempting to crack topped crude for a satisfactory pressure distillate hit the charge too heavy which resulted in a high production of fixed gases, reported in some instances as great as 25 to 30 percent. In the past two or three years, processes have been revised, and refining technique has been developed so that cracking of the refractory stocks is no more difficult than West Texas, or any other crude leaning heavily to the paraffinic series.

Given a refining plant, basically sound from an engineering standpoint, and operated by a competent staff, a refiner in Michigan running topped crude can produce a gasoline comparable to products manufactured elsewhere, and with no greater percentage of fixed gases and processing loss. Due to successful and satisfactory results obtained by cracking topped Michigan crude in a Dubbs plant at Alma, Mid-West Refineries, Inc., completed a two-coil, selective crack-



The heavy oil charge to the furnace is split into two streams by separate lines from the charge pump.

ing unit at Grandville in 1941. This plant was designed by the technical staff of Frick-Reid Supply Corporation under the supervision of Universal Oil Products Company.

A day of typical operation of this plant, in run No. 3 since beginning operation, and the eighty-second day of this run, while operating on a charge of 27° API topped Michigan crude, produced 54.78 percent of 387°F. end point pressure distillate having an API gravity of 62.5°, and an octane of 62.7 motor method. In addition to the pressure distillate, the plant produced 1.28 percent of polymer gasoline, .031 percent of cracked distillate for diesel fuel and 36.71 percent of 6.8° API residum as industrial fuel oil. The gas and loss on this date, which is average, was 7.32 percent.

A break-down of the operation for this day is as follows:

	Percent	Barrels
Charge 27° API Topped Crude	100.00	2,150
Gasoline	54.78	1,177.770
Polymer Gasoline	1.28	27.520
Cracked Distillate	0.31	6.665
Residuum	36.31	780.665
Gas and Loss	7.32	157.380
	100.00	2,150.000

The raw topped crude is charged to the main fractionating tower, operated at 75 pounds pressure. The charge enters the tower above the seventeenth bubble deck. The fractionating column has 16 bubble plates and 8 side-to-side pans in addition to the light-oil reservoir, between the eleventh and twelfth bubble plates. The inside of the column is lined with gannister from the base above the skirt to the eleventh plate and equipped with safety valves adjusted to 95 pounds.

The heavy hot oil is handled with a horizontal duplex, double plunger outside packed hot oil pump. Suction is taken at the base of the main fractionating column at 75 pounds and discharged at 630 pounds to the heavy oil furnace.

The furnace is a center wall updraft heater containing 164, 38-foot tubes. Each side of the heater contains an equal number of tubes: 40 convection tubes on 5-inch centers, 5 shock tubes on 7-inch centers, 10 hip tubes and 27 wall tubes both on 5¼-inch centers.

The charge of heavy oil is split at the hot oil pump which is fitted with two separate discharge lines, one from each side which connect the pump side with its respective side of the heavy-oil-heater tube bank. The heater is fired from both sides with combination gas and oil burners with controls to obtain a transfer temperature from both banks of tubes of 906°F. The recycle ratio of the heavy oil side of the plant is approximately 4:1.

The light oil charge with an API gravity of 27.2° and an end point of 595°F., is taken from the accumulator section of the main column with a horizontal duplex double plunger, outside packed pump. The discharge pressure of this pump is maintained at 670 pounds with the material flowing to the light oil heater. This furnace contains 138 tubes, 65 in the convection section, followed by the shock and hip tubes and the wall tubes. The temperature maintained on the transfer from the light oil furnace is 1016° F., with the commodity flowing to the top of the reaction chamber where it enters through a separate nozzle from that which carries the heavy oil.

The reaction chamber is designed for an operating pressure of 325 pounds, but is held normally at 280 pounds. The chamber is finished inside with an alloy lining. The control valve on the outlet of this column is a free-flow angle unit which has a 600-pound working-pressure body. The valve is equipped with a pressure controller with a wide adjustable line throttling range steel pressure element. This valve controls the flow of the commodity from the reaction chamber outlet from a vessel pressure of 280 pounds to a line pressure of 80 pounds.

An 8-inch insulated line carries the material from the reaction chamber to the spreader plate in the flash chamber, which is equipped with a chamber for the removal of residuum. The temperature of the inlet of the flash chamber is 845°F., and the top carried at 804°F. The draw-off temperature averages 775°F., while the residuum which flows through fuel oil coolers is reduced to 300°F. running to storage, and which has a viscosity of 75 and a flash of 152.

Vapors flow from the top of the flash chamber through a 10-inch line to the main column which is operated with a base temperature of 710°F. The accumulator section where the light oil is removed has a temperature of 585°F., and the top of the column is held at 357°F. with reflux. Two pumps discharge normally to the reflux connection at the top of the column, one carrying pressure distillate and the other a low-end-point straight-run gasoline from the topping plant. The straight-run gasoline used as reflux to control the top temperature of the main column, in addition to the normal reflux from the pressure distillate receiver amounts to 365 barrels daily. This practice has resulted in a finished gasoline of slightly lower basic octane than straight cracked pressure distillate, but has made possible the utilization of straight-run where the completed gasoline may be finished with lead to produce a premium motor fuel.

The total condensate and crack pressure distillate is pumped to the stabilizer and enters on the fourteenth plate through a 2-inch transfer line. The column pressure, when producing an 8½-pound RVP gasoline, is held at 175 pounds, and the top maintained at a temperature of 125°F. The reboiler heated with a side-cut from the main column is operated at 362°F., and reflux pumped back to the stabilizer at 102°F.

Vapors from the stabilizer overhead outlet pass to a 16-plate absorber which is operated with absorption oil in the conventional manner. The column pressure is maintained at 70 pounds with the fat oil returned to the plant where it is employed as low-pressure cooling oil and to control cracking at points necessary. Vapors released by the absorber contain an average of 35 percent olefins which are recovered as polymer gasoline in a small catalytic unit. The gas to the polymerizing unit is diluted with recycle to an average olefin content of 17.7, and the residue from the unit contains only about 3 percent olefins. The recovery of olefins is about 55 gallons of product per pound of catalyst, and the product condensed has a gravity of 64.5° API, and a RVP of 10 pounds.

The combined stream of gasoline is pumped through a two-stage caustic unit; the first to remove the hydrogen sulphide, and the second to reduce the percentage of mercaptans before treating.

Fundamentals of Refinery Piping Design

PART II—Anchors and Supports

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A GOOD anchor is just as important as a good expansion bend in piping design. For an overhead line the tie rods anchored to the base of the pipe support themselves or to special deadman provide an inexpensive anchorage. Figure 1 illustrates the problem.

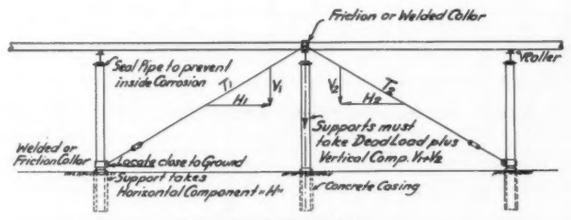
For underground lines or lines close to the ground a concrete block is used for the purpose. The friction between concrete and the earth in the ultimate analysis is the only dependable factor for the transmission of forces and therefore the friction surface should be made as large as possible. Short postholes filled with concrete, reinforced with some scrap rods, form a very effective, cheap friction pile as shown in Figure 2.

For pipe support, structural steel sections, special thin-walled pressed-steel sections, secondhand or new pipes, concrete or wooden poles may be used.

Contrary to popular belief, wooden columns are far more fire resistant than the unprotected steel sections, especially those made of thin pressed plates. Wooden columns will char on the surface, but do not lose strength and will last for hours where steel may collapse within a few minutes. Creosoted poles are cheaper, do not require painting and protective concrete foundations. They are easily installed, moved around, recovered and are plenty strong for any loads usually encountered in the practice. In dangerous locations the wooden top beams can be made reasonably fire resistant by thin sheets of galvanized iron nailed directly to them.

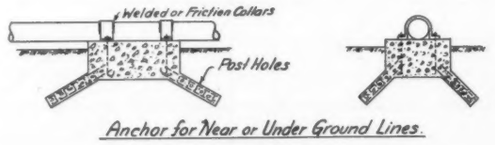
Figure 3 shows a suggested arrangement using creosoted poles for pipe supports.

Figure 4 gives a tentative design for stanchions or


Anchors and Pipe Supports.
Friction or Welded Collar
Roller
Seal Pipe to prevent inside Corrosion
Welded or Friction Collar
Locate close to Ground
Support takes Horizontal Component = H
Supports must take Dead Load plus Vertical Comp. V1+V2
Concrete Casing

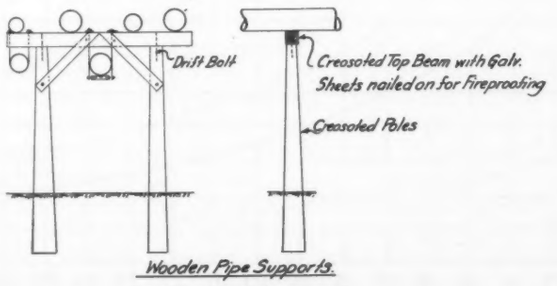
Anchor for Overhead Line.

FIGURE 1



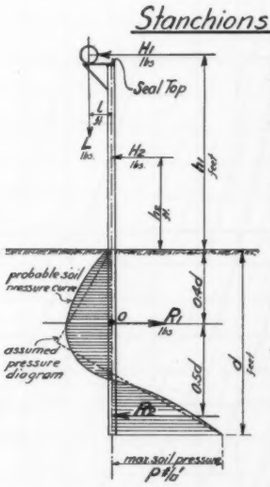
Anchor for Near or Under Ground Lines.

FIGURE 2



Wooden Pipe Supports.

FIGURE 3



Design assumptions for Coast

Soil bearing values increase regularly by 500 lb/ft² with every foot of depth. Thus at 2 ft. the safe bearing p = 1000 lb/ft²; at 6 ft. p = 3000; at 10 ft. p = 5000 lb/ft² etc. The Point of Rotation "O" is located 0.4d below the surface and the distance between the Reactions R1 and R2 is equal to 0.5d.

Bending Moment at "O":

$$M_o = H_1(h_1+0.4d)+H_2(h_2+0.4d)+L.l$$

Reactions:

$$R_2 = \frac{M_o}{0.5d}$$

$$R_1 = R_2+H_1+H_2$$

Max. soil pressure:

$$p = \frac{12M_o}{bd^2}$$

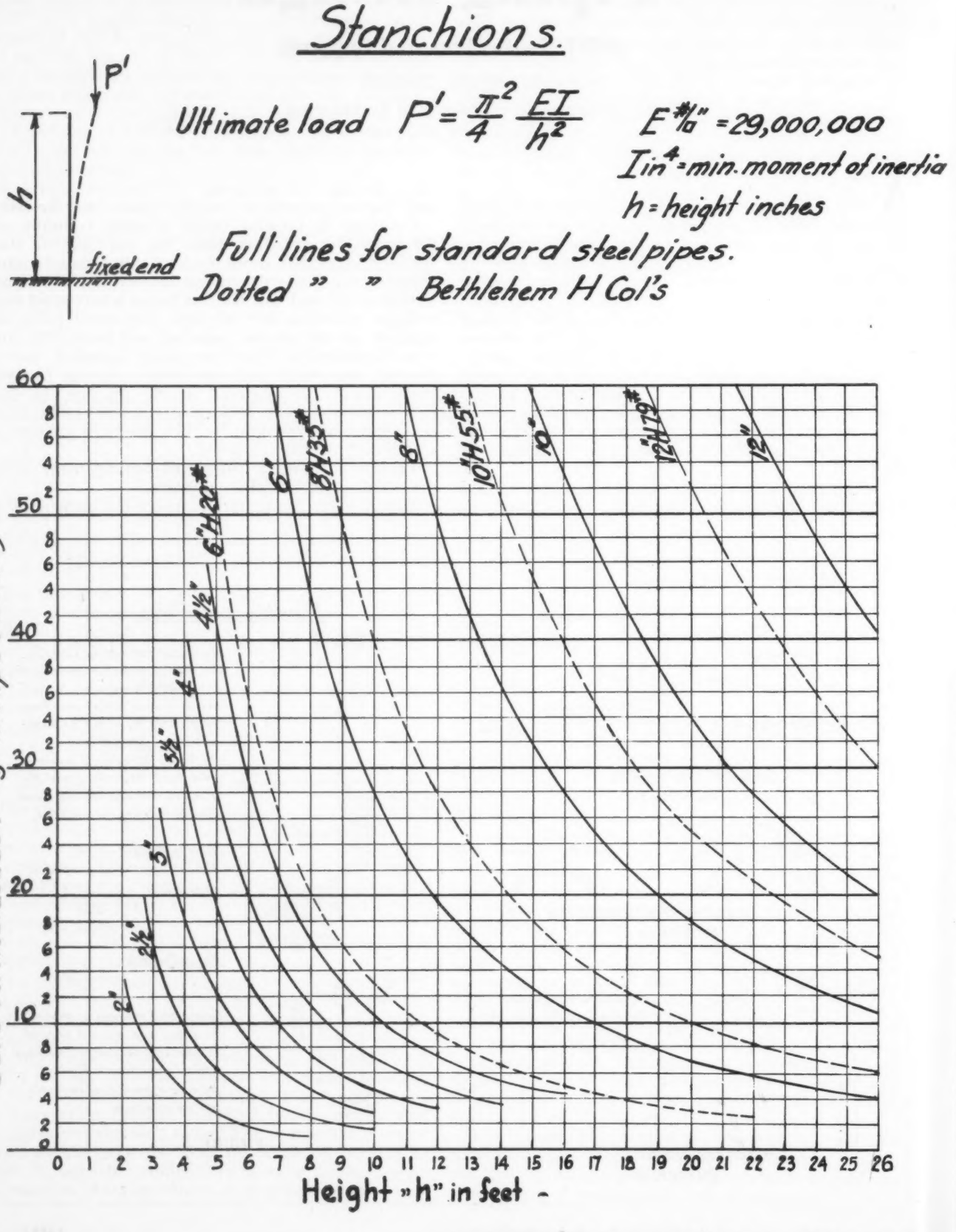
For the most economical design the dimensions d and b should be selected so that the combined cost of excavation, length of pipe and quantity of concrete will be minimum

FIGURE 4

poles with soil pressure formula. Structural shapes or wood may be used instead of pipe shown in the picture.

Figures 5 and 6 are useful for determining the carrying capacities of pipes and Bethlehem H sections when used as columns.

When a horizontal pipe line is supported at intermediate points, sagging of the pipe occurs



Pipe Data for Stanchion Design. Fig. 6.

Size in.	O.D. in.	Standard I in⁴	S in³	a in²	r in	W lb/ft	Extra Strong I	S	a	r	W
1	1.315	.09	.13	.49	.42	1.69	.11	.16	.64	.41	2.17
1½	1.9	.31	.33	.80	.62	2.74	.39	.42	1.07	.61	3.63
2	2.375	.67	.56	1.07	.79	3.65	.87	.73	1.48	.77	5.02
2½	2.875	1.53	1.06	1.70	.95	5.80	1.92	1.34	2.25	.92	7.66
3	3.5	3.02	1.72	2.23	1.16	7.66	3.89	2.23	3.02	1.14	10.25
3½	4.0	4.79	2.39	2.68	1.34	9.11	6.28	3.14	3.68	1.30	12.5
4	4.5	7.23	3.21	3.17	1.51	10.8	9.6	4.3	4.41	1.48	15.0
4½	5.0	10.55	4.22	3.73	1.68	12.7	14.1	5.6	5.18	1.65	17.6
6	6.625	28.1	8.5	5.58	2.25	19.0	40.5	12.2	8.40	2.19	28.58
8	8.625	63.4	14.7	7.26	2.95	24.7	105.7	24.5	12.76	2.88	43.4
8	"	72.5	16.8	8.4	2.94	28.6					
10	10.75	126.0	23.4	9.18	3.70	31.2	212	39.4	16.10	3.63	54.74
10	"	137.4	25.6	10.0	3.69	34.2					
10	"	160.7	29.9	11.91	3.67	40.5					
12	12.75	245.5	39.0	12.88	4.39	43.8	361.5	56.7	19.24	4.33	65.4
12	"	279.3	43.8	14.58	4.38	49.6					

Size	O.D.	Double Extra Strong I	S	a	r	W
1	1.315	14	.21	1.08	.36	3.66
1½	1.9	.57	.60	1.88	.55	6.4
2	2.375	1.31	1.10	2.66	.70	9.03
2½	2.875	2.87	2.0	4.03	.84	13.7
3	3.5	6.0	3.42	5.47	1.05	18.6
3½	4.0	9.85	4.9	6.72	1.21	22.9
4	4.5	15.3	6.8	8.10	1.37	27.5
4½	5.0	22.6	9.0	9.6	1.54	32.5
6	6.625	66.3	20.0	15.64	2.06	53.2
8	8.625	162.0	37.6	21.20	2.76	72.5

Size	Bethlehem H Col's weight	I_y^x	S_y^x	r_y^x	Area
6	20*	39.1 13.0	13.03 4.34	2.58 1.49	5.89
8	35	123.0 41.1	30.7 10.28	3.46 2.0	10.3
10	55	300.4 100.4	60.1 20.1	4.32 2.50	16.12
12	79	623.1 208.2	103.9 34.7	5.18 2.99	23.23

FIGURE 6

between these supports, the amount of sag being dependent upon the weight of the pipe, water, insulation, and valves or fittings which may be included in the line. If the pipe line is installed with no downward pitch, pockets will be formed in each span in which case condensation may collect if the line is transporting steam. In order to eliminate these pockets, the line must be pitched downward so that the outlet of each span is lower than the maximum sag.

Tests to determine the deflection of horizontal standard pipe lines filled with water, in pipe sizes ¾-inch to 4-inch inclusive, have indicated that for pipes larger than 2-inch and with supports having center-to-center dimensions greater than 10 feet, the resultant deflection is less than that determined by the use of the formula for a uniformly loaded pipe fixed at both ends. For pipe sizes 2-inch and smaller, the test deflection was in excess of that determined by the formula for pipe having fixed ends and approached, for the shorter spans, the deflection as determined by the use of the formula for pipe lines having unrestrained ends.

Figure 7 gives the deflection of horizontal standard pipe lines filled with water, for varying spans, based upon the results obtained from tests for sizes 2-inch and smaller, and upon the formula for fixed ends for the larger sizes of pipe. The deflection values given on the chart are twice those obtained from test or calculated, to compensate for any variables including weight of insulation.

The pitch of pipe lines is usually expressed as so many inches in a certain number of feet. This expression is called the "average gradient" of the pipe line. The formula given below indicates the maximum length of unsupported piping which can be permitted without allowing the deflection of each span to exceed the drop in elevation.

$$\text{Average Gradient} = \frac{144S^2y}{36S^2 - y^2}$$

where:
S = Length of one span, feet
y = Deflection of one span, inches

The dotted lines as shown in Figure 7 are plotted from the above formula and indicate average gradients of 1 inch in 10 feet, 1 inch in 15 feet, 1 inch in 20 feet, 1 inch in 30 feet, and 1 inch in 40 feet.

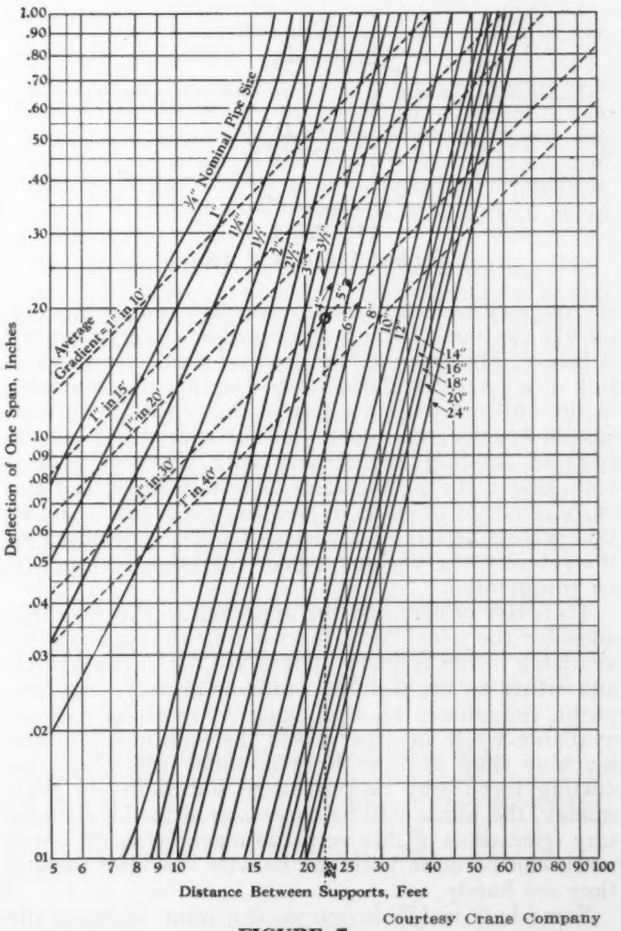
Example

What is the maximum distance between supports for a 4-inch standard pipe line, assuming a pitch or average gradient of 1 inch in 30 feet?

Proceed downward from the intersection of the diagonal dotted line for an average gradient of 1 inch in 30 feet and the diagonal solid line for 4-inch pipe to the bottom line where it is noted that the maximum span is approximately 22 feet.

Deflection of Horizontal Pipe Lines

(Based on Standard Pipe Filled With Water)



Courtesy Crane Company

FIGURE 7

Welding Grooves in Refinery Practice

WELDON L. ARCHER

SINCE welding deals with the application of fluid steel, there is the matter of groove and joint design that merits attention. If the only requirement were a trough to hold the molten metal, there would be no need for an article dealing with groove delineation. However the function of the joint is to bond the two pieces together as one and there are attendant questions of weld soundness, cost and technique that are intimately bound up in the whole question of proper welding in the refinery.

Because of the limitations that have ben described,

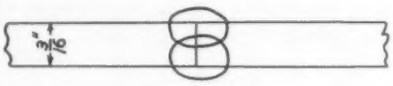


FIGURE 1-A
Ungapped Square-Butt Joint.

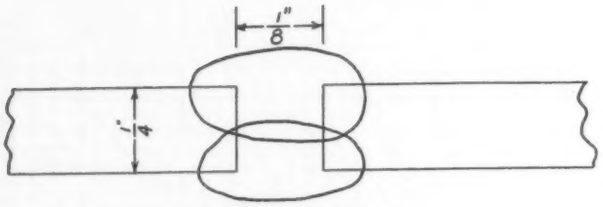


FIGURE 1-B
Gapped Square-Butt Joint.

the refinery cannot afford to overlook the problem of groove contours. First and foremost in every refinery is safety. Therefore a fundamental need in the selection of a correct welding groove is that of soundness in the finished weld. Of course the refinery engineer cannot be expected to combine the specialized knowledge of welding engineering with that of refinery technology. He is dependent upon outside aid for the more important details of welding procedure. And in this second article of a series of four on welding in the refinery the various aspects of joint design will be enumerated.

To better understand the approach to this problem consider the usual tools for welding that are readily available in the refinery. These are the cutting torch and either an arc-welding outfit or an oxy-acetylene outfit. Sometimes an abundance of machine tools is available while in other cases the equipment in the machine shop is more limited. Since the automatic cutting torch may be purchased for relatively little money, the joints will be those suited to the elementary operations of this versatile machine as the same work can be done with the heavier machine tools if they are handy.

Some butt welds do not need a joint. Because the welding groove has a specific function in welding, there is no sense in preparing grooves where none are necessary. Thus the butt joints of Figure 1 are known as square-butt joints and are prepared without a gap as in Figure 1A or with a gap as in Figure 1B.

What are the limitations of the square-butt joint? That is a mighty important question. For the joint has some well established boundaries beyond which its utility diminishes rapidly. Thickness is the outstanding influence on the application of the square-butt joint. For light-gauge metal where welding is to be done from one side only, the heaviest gauge should be in the neighborhood of 3/32-inch. That is the limit of penetration along with satisfactory weld uniformity and quality. Should the joint lend itself to welding from both sides, the gauge may be doubled to 3/16-inch with an expectancy of good results. And by gapping the joint and welding from both sides the upper thickness limit may well be ¼-inch.

At this point it may be worthwhile to mention that

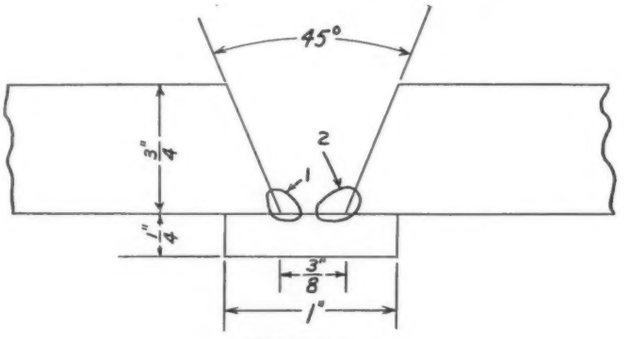


FIGURE 2-A
Single V with Backing Strip.

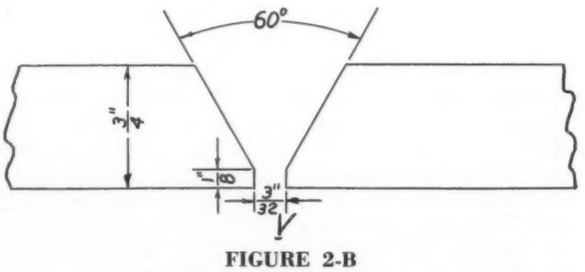


FIGURE 2-B
Single V Joint.

all of the grooves reviewed are considered in the light of an extensive welding experience. An effort has been made to be conservative. No suggestions are made leaving any possibility of failure in the field. Now gapped butt welds have been used to join plates and pipe ⅜-inch thick without beveling the plates in any way. With very strict and ubiquitous control of

TABLE 1
Recommended Dimensions for Plug Welds

Plate Thickness	Root Diameter of Plug Opening	Sidewall Bevel
⅛	¼	45°
¼	½	45°
⅜	¾	45°
½	⅞	45°
¾	1	45°
1	1¼	60°
1½	1½	60°

welding, and again from experience such a state of affairs exists more in fancy than in everyday work, this joint might prove both economical and safe. But from a practical viewpoint that extra ⅛-inch has the same relationship to sound welding practice as cutting the factor of safety from 4 to 3 might have in the design of a fractionating tower. More than ever before we cannot gamble with safety these days when every drop of production has a ready market.

Above ¼-inch in thickness a bevel allows the welder to carry on his work. For thicknesses greater than ¼-inch and up to and including ¾-inch the single-vee joint has made a good record. Two types of joints are considered in Figure 2. Figure 2A illustrates the single-vee groove using a backing strip while Figure 2B is the single-vee without backing strip.

Both designs are good. The one embodying the backing strip calls for a little more material than the one without but offers other inducements to offset the greater material use. Wherever inexperienced welders, or welders who are not the very finest, are assigned to critical welding jobs, the backing strip serves a worthy purpose. Simple fillet welds such as beads 1 and 2 in Figure 2A start the weld. These fillets are easily made. They effectively seal the bottom of the joint against magnetic interference. And they provide sound metal of known degree of penetration as a good start for any butt weld.

Notice the generous spacing at the bottom of the groove of Figure 2A. Adequate space is allowed for the manipulation of the weld metal. For metallic arc welding the two fillets are made while for oxy-acetylene welding the entire bottom of the joint is filled with weld metal. The over-all bevel is 45°, 22½° for each edge bevel, which is less than that provided for Figure 2B. The larger gap permits the use of a smaller over-all angle.

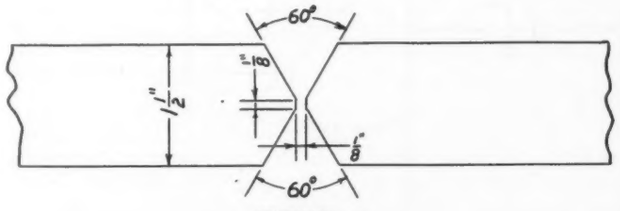


FIGURE 3
Double V Butt Joint

More skilled welders may be given a joint of the contour shown in Figure 2B. Now the included angle becomes 60°, 30° on a side, to furnish enough room for welding and cleaning operations. The joint is gapped at the bottom to make uniform penetration possible while a lip is specified to furnish adequate heat capacity at the bottom of the groove.

At first glance a paradox exists here: a gap to allow penetration and a lip to supply heat capacity, thereby avoiding too much penetration. Unless there were a gap the best welder in the world would have a trying time while he attempted to burn through the bottom of the joint for his needed penetration. With the gap and pointed edges his job would be just as difficult as the metal would melt away too rapidly, leading to the formation of steel stalactites or icicles on the underside of the joint. With a lip, however, the heat capacity of the base metal works together with the surface tension of the weld metal to bring about the exact degree of penetration that characterizes a well made single-butt weld without backing. This

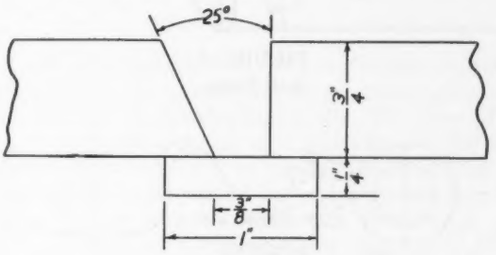


FIGURE 4
Single Bevel Butt Joint.

groove is difficult but may be employed with able welders.

Where double-butt welds of a thickness greater than ¾-inch are encountered, the double vee joint of Figure 3 is most useful. In essence this joint provides all of the features of that illustrated in Figure 2B with a provision for welding from both sides. This groove necessitates chipping to sound metal before the second side of the weld is started.

The joints outlined to this point are those best adapted to the following welding positions: flat, vertical and overhead. Horizontal welds permit the application of a single-bevel-butt joint such as that shown in Figure 4. Here a horizontal flat shelf is provided allowing the deposition of beads of weld metal to make-up a good weld.

Next in popularity to the butt joint is the lap joint. Here, too, there are design considerations to be encountered. Among the most important of these are amount of lap and plug welding. Nor are plug welds alone to be used as there may be places where a slot weld is more desirable. Figure 5 depicts a proper lap weld while Figure 6 shows both the plug weld (Figure 6A) and the slot weld (Figure 6B). The dimensions of these welds are a function of diameter with the following tables representing good practice. Fusion at the bottom of the joint is the major point to be watched in both the design and the execution of plug and slot welds.

Corner joints may be used in some designs although this joint is not always considered to be as fundamentally good as some of the others described previously. Two types: one formed by the position of

TABLE 2
Recommended Dimensions for Slot Welds

Plate Thickness	Length of Slot	Width of Slot
⅛	¾	¼
¼	1½	½
⅜	1½	¾
½	2	1
¾	2	1
1	2	1
1½	2½	1¼

the pieces alone and the other grooved are commonly selected.

In Figure 7 the corner joint with a groove provided by the location of the pieces may be studied. For the purposes of root fusion a slight gap may be shown. No lip is required as this joint has relatively good heat capacity as it stands. The corner joint of Figure

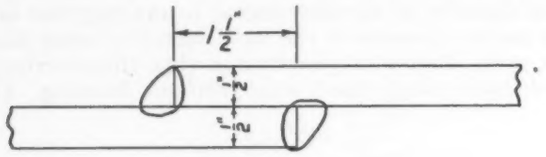


FIGURE 5
Lap Joint.

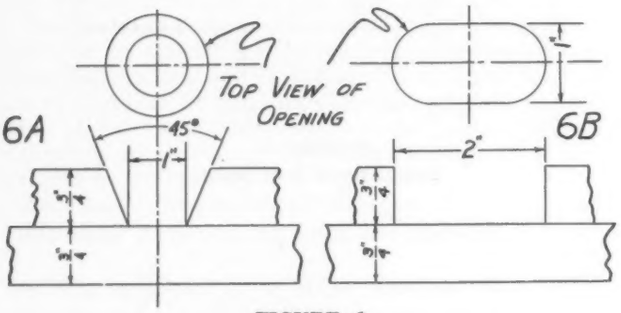


FIGURE 6
Plug and Slot Designs.

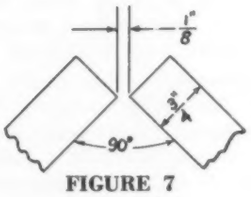


FIGURE 7
Corner Joint.

7 sometimes is completed with a small fillet on the underside of the joint after the first side has been welded. Chipping to sound metal is recommended here as in any other joint in which weld metal is applied from two sides.

The double bevel corner joint with an added fillet is a good basic design. Enough metal is added in the right places to make this groove, pictured in Figure 8, a favorite of designing engineers confronted with the necessity of making a flat head or a flat closure where the advantages of a formed part must be foregone due to the exigency of a repair.

The edge joints of Figures 9 and 10 may be used where the parts are subjected to little stress. Floats and similar parts that must resist very little pressure are often constructed of light-gauge steel joined with the edge weld of Figure 9. Structural welds employing the grooved edge weld of Figure 10 have a place in the refinery. But for stressed applications or where there is any element of doubt in the design, the edge weld must be acknowledged to have certain drawbacks.

U and J joints have been eliminated from this discussion because their preparation is generally restricted to the heavier machine tools. Now, however, the development of the grooving torch has made possible the bevelling of both U's and J's with the oxy-acetylene process. The work requires a degree of skill that comes from the practice afforded by a relatively large volume of work so that the amount of bevelling required can be the determining factor in the selection of this method. Where much heavy seam welding is anticipated, the U and J groove may well save enough welding time and material to warrant the more expensive joint preparation involved in these latter types.

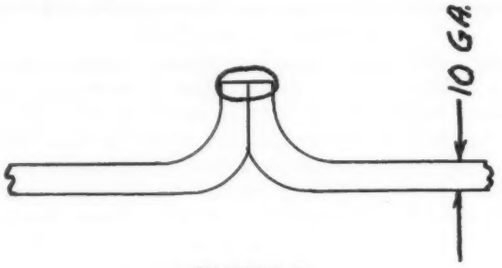


FIGURE 8
Double Bevel Corner Joint.

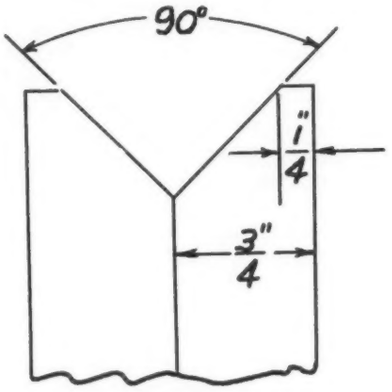


FIGURE 9
Edge Joint.

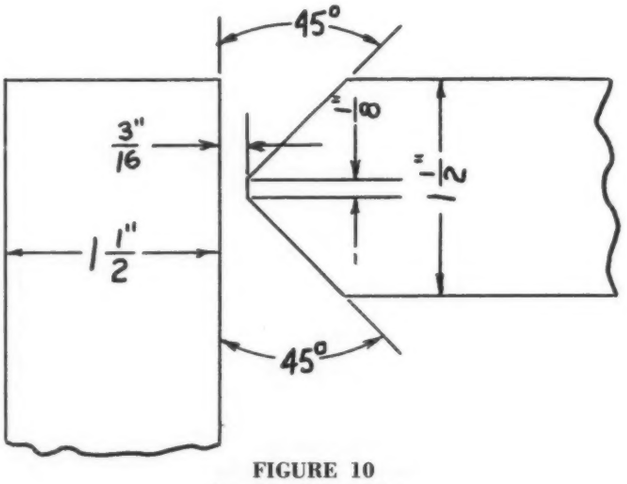


FIGURE 10
Beveled Edge Joint.

Butt joints are well suited to many types of loads. Both tension and compression stresses are accommodated by this joint. Fatigue loads, too, are handled well. In the latter case the weld should be perfectly sound throughout if stress concentrations and premature failures are to be avoided. Strict adherence to the details and dimensions suggested should enable

[*Continued on page 90*]

Changes Occurring in Oils and Engines From Use*

FRANK A. SUESS, H. C. BALDWIN, W. A. JONES, BERT H. LINCOLN
Continental Oil Company

THE problem of lubricating automotive engines is an active one which is far from completely solved even though each succeeding year shows marked improvement in the quality of the average lubricant. The engine manufacturers' desire or necessity of improving engine design will no doubt prevent complete solution of all lubricating problems. Before lubricants are developed to withstand all present engine punishment, more engine punishment for the oil will be provided.

In a broad general consideration of lubricating oils and engines, there are two questions of almost equal interest. One concerns the changes in lubricating oil while in service in an engine. The other concerns the changes which occur in an engine in service with a lubricating oil. From a theoretical viewpoint, there should probably be no change in either the lubricating oil or in the engine during use—from a practical viewpoint, we are a long way from any such perfect system. It may be assumed, however, that any change which occurs in either the lubricating oil or the engine during use is objectionable.

There are numerous factors which determine the nature and degree of the changes in both the engine and the oil during use. Some of the known factors are physical and chemical nature of the lubricating oil, design and condition of the engine, conditions of service, such as speed, load, duration, ventilation, temperature, extraneous material from fuel, cooling system, combustion zone air, or other sources. Each of these factors and various combinations may affect different lubricating oil-engine systems differently.

Accordingly, the study and rating of oils and engines must include a study of many combinations of the more severe of all of these factors. Reliable information cannot be obtained by one piece of laboratory equipment, or a single type of engine, or a single set of service conditions. To rate accurately lubricating oils or engines, a large number of tests on several pieces of equipment operated under a number of different sets of operating conditions is required. Each distinct test will produce a large number of types and degrees of change in both the oil and the test equipment, which must be isolated, evaluated, and recorded for comparison. Such a test program faithfully carried out will produce a volume of data so large that conclusions and predictions are impossible without tabulating, correlating, and digesting all the data.

In outline, data are presented to show the changes which occurred in the lubricating oils and the engines during use in a comprehensive study which culminated in the road tests mentioned by Sibley et al.[6] Prior to these road tests, a very extensive study was made of 12 commercial oils marketed as premium-grade oils by the predominant oil companies and 14 experimental or development oils. Of these 26 oils, three of the commercial oils and two of the experimental oils were found to display outstanding merit. These oils were therefore selected for extensive road tests, and this paper includes a discussion of the service changes in these oils and engines as follows:

I. Lubricants and equipment used.
II. Chemical laboratory and mechanical laboratory investigations.
III. Road tests.

The data support the observations and conclusions presented and permit others to evaluate the data for different or additional conclusions.

I. Lubricants and Equipment

Since these investigations were made on certain lubricating oils and certain investigational equipment, it is necessary to define each clearly.

Data from the investigation of five lubricating oils manufactured by some of the largest and most reliable oil companies have been tabulated and correlated for this report. Not all of the five oils were tested on all of the groups of road test units.

The physical and chemical characteristics of the five oils are listed in Table 1. Oil II is a solvent-treated, Mid-Continent paraffin-base oil blended with two addition agents. One of these addition agents is Thialkene Inhibitor,[1] a sulfur-type anti-oxidant and corrosion inhibitor. The other is methyl di-chlor stearate,[2] added to increase oiliness and load-carrying capacity. Oil I is identical with Oil II with the exception that a different sulfur-type anti-oxidant[3] and corrosion inhibitor is used. The other three oils selected from the results of the preliminary chemical and mechanical laboratory investigations represent the top quality lubricating oil of three of the leading manufacturers. Test conditions were designed to represent the most severe conditions likely to be encountered in service and were sufficiently severe to reveal differences in superior grades of oils.

Equipment

The equipment used in this series of tests includes the oxygen-absorption apparatus and the modified Underwood apparatus for chemical laboratory testing. Two each of three makes of engines, groups F, G, and H, mounted on stands and connected to calibrated fans, were used for mechanical laboratory testing. Four groups of automotive equipment were used in high-speed, high-temperature road tests. Each group consisted of four identical units, and these groups will be referred to as A, B, C, and D.

The oxygen-absorption test described by Davis et

*Before the National Fuels and Lubricants meeting of the Society of Automotive Engineers, Tulsa, October 23 and 24, 1941.

TABLE 1
Physical Characteristics of Oils Tested

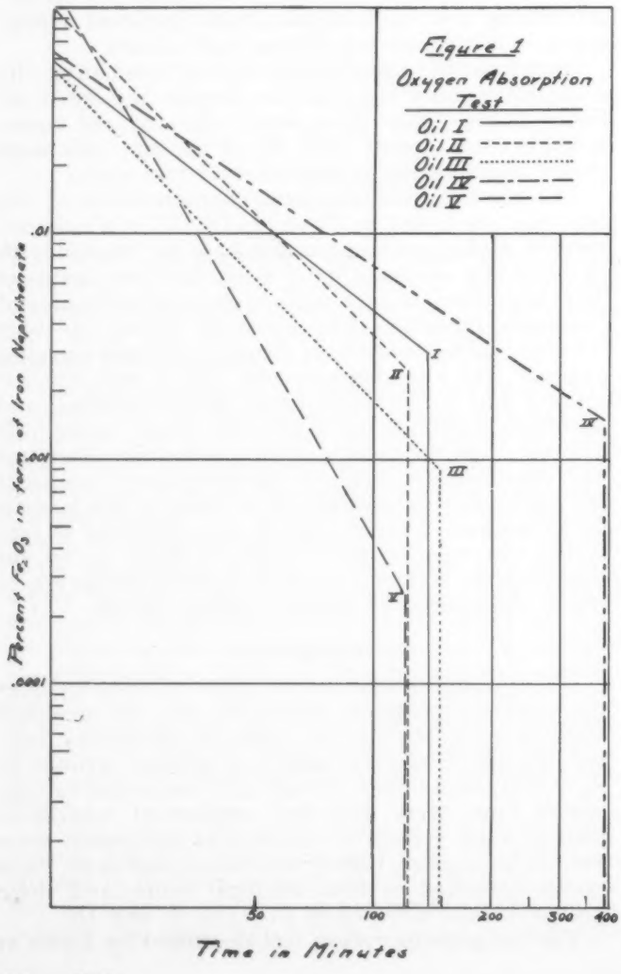
	Oil I SAE 20	Oil II SAE 20	Oil III SAE 20	Oil IV SAE 20	Oil V SAE 20	Oil I SAE 30	Oil II SAE 30	Oil III SAE 30	Oil IV SAE 30	Oil V[1] SAE 30
Gravity	30.6	30.6	31.3	29.3	29.1	30.6	30.7	28.9	28.7	29.5
Flash, °F	450	450	415	435	430	480	480	450	450	445
Fire, °F	515	515	470	500	490	550	550	510	510	510
Viscosity at 100° F. centistokes	70.8	70.8	66.45	72.95	74.9	93.3	93.8	121.8	109.1	91.8
Viscosity at 100° F. S.S.U.	327	327	307	337	346	431	433	562	504	424
Viscosity at 210° F. centistokes	8.71	8.71	8.77	8.39	8.77	10.42	10.48	12.42	10.80	10.38
Viscosity at 210° F. S.S.U.	54.8	54.8	55	53.7	55	60.7	60.9	67.9	62.0	60.5
Viscosity index	104	104	112	91.5	100	100	102	101	89	103
Pour Point, °F	5	5	—20	0	—5	10	10	—10	0	20
Color, A.S.T.M.	3—	3—	5+	1½+	4½+	2½	3	5	2+	5—
Color, true-color Units*	16	16	44	4	37	13	18	42	9	40
Steam emulsion number	90	90	960	90	120	90	90	420	150	150
Herschel demulsibility	1,200	1,200	20	600	1,620	1,200	1,620	270	1,320	1,620
Neutralization number	0.03	0.025	0.05	0.03	0.05	0.03	0.015	0.06	0.04	0.05
Saponification number	2.50	1.84	0.30	0.45	0.20	2.46	1.34	0.31	0.37	0.21
Conradson carbon residue, percent	0.01	0.01	0.28	0.04	0.33	0.03	0.04	0.37	0.06	0.21
Sulfur, percent	0.38	0.38	0.10	0.21	0.18	0.18	0.18	0.23	0.21	0.08
Chlorine, percent	0.068	0.070	0.00	0.00	0.00	0.068	0.073	0.00	0.00	0.00
Phosphorus, percent	0.00	0.00	0.010	0.012	0.010	0.00	0.00	0.008	0.012	0.00

* In the examination of oils, the color is reported in true color units determined by the procedure of Parsons and Wilson (4). The use of this color scale also permits comparison of colors of used oils which are far darker than the range of the conventional color scales.

TABLE 2
Oxygen Absorption Test—SAE 20

	OIL I		OIL II		OIL III		OIL IV		OIL V	
	Comparative Percentage of Reciprocals		Comparative Percentage of Reciprocals		Comparative Percentage of Reciprocals		Comparative Percentage of Reciprocals		Comparative Percentage of Reciprocals	
Stability Minutes	138	100	121	114	148	93	389	35	120	115
Iron Tolerance, percent, Fe_2O_3	.0030	100	.0025	120	.0009	333	.0015	200	.00025	1200

al[5] indicates the tendency of a particular oil to absorb oxygen and its sensitiveness to the catalytic effect of metal in organic combination in accelerating oxygen absorption.



The modified Underwood[5] test gives information regarding the tendency of an oil to form products corrosive to metals. This test equipment differs from an automotive engine in that extrinsic soluble or reactive catalysts, such as lead from the combustion chamber, do not contaminate the oil during the test. Some information is given by the modified Underwood test regarding the predominating types of deterioration products which the oil will have a tendency to develop in automotive service.

Mechanical Laboratory
Engine Groups F, G, H—Stand Tests

The engines of groups F, G, and H used in the mechanical laboratory were selected to give the maximum amount of information concerning the oils tested and their effect on engine condition and performance. Accordingly, the engines were selected to include the greatest range of engine materials and engine design consistent with the limits of a reasonable number of test engines. It was found that three makes of the larger production passenger car engines included substantially all of the more important factors normally expected to cause variation in oil-engine systems in service. Two engines of each make were operated simultaneously with each oil to provide check runs to assure the accuracy of the data. The variables in engine design included:

1. Pressure and pressure-splash lubricating systems.
2. Low-pressure and high-pressure lubricating systems.
3. Overhead and "L" head designs.
4. Trunk and constant clearance or "T" slot pistons.
5. Tin-plated cast-iron and aluminum alloy pistons.
6. All rings above the piston pin and rings both below and above piston pin.
7. Rolled bronze and aluminum bronze piston pin bushings.
8. Crankcase ventilation rates from 26 to 225 cubic feet per hour at 60-65 miles per hour speed range, as specified by the respective manufacturers.

In the operation of these three groups of engines,

TABLE 3
Modified Underwood Tests—SAE 20

	OIL I		OIL II		OIL III		OIL IV		OIL V	
	Hours	Comparative Percentage of Reciprocals	Hours	Comparative Percentage of Reciprocals	Hours	Comparative Percentage of Reciprocals	Hours	Comparative Percentage of Reciprocals	Hours	Comparative Percentage of Reciprocals
Hours Before Bearing Corrosion:										
Copper-Lead	15	100	11	136	5	298	16	93	8	187
Cadmium-Silver	12	100	12	100	6	200	16	77	13	93
Hours to Develop:										
Neutralization number of 3.0	14	100	12	117	10	141	18	77	11	128
Sludge—of 1.0 percent	16	100	12	134	24	68	20	81	12	134
Viscosity Increase, of 25 percent	14	100	13	108	8	176	18	77	10	141
Conradson Carbon Residue, of 2.0 percent	15	100	14	106	9	166	19	79	11	136
Resin, of 10 percent	12	100	11	109	8	151	18	67	11	109
Average		100		111		180		79		133

SAE 30

Hours Before Bearing Corrosion:										
Copper-Lead	11	100	12	91	9	122	17	65	3	366
Cadmium-Silver	11	100	12	91	9	122	17	65	2	550
Hours to Develop:										
Neutralization number of 3.0	12	100	17	71	8	150	18	67	5	240
Sludge—of 1.0 percent	18	100	20	91	18	100	24	76	24	76
Viscosity Increase, of 25 percent	12	100	14	86	6	200	18	67	4	300
Conradson Carbon Residue of 2.0 percent	13	100	13	100	10	130	19	69	4	322
Resin of 10 percent	9	100	10	90	5	180	18	50	2	450
Average		100		89		173		67		329

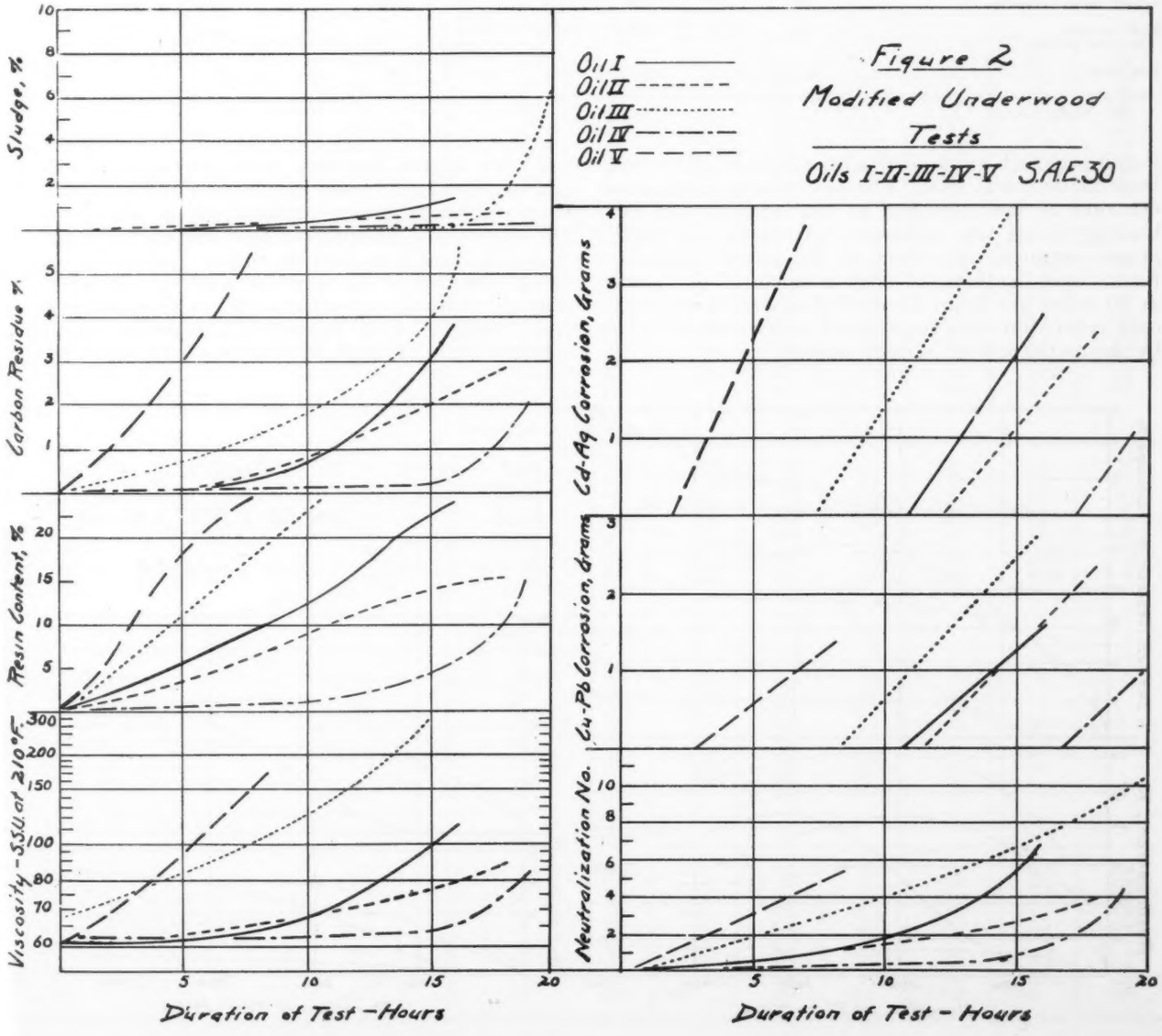


TABLE 4
Progress of Formation of Products of Change in Oil I in Mechanical Laboratory Test Engines

	Group F—Engine No. 1—Oil I					Group G—Engine No. 2—Oil I				
Miles	1,000	2,000	3,000	4,000	5,000	1,000	2,000	3,000	4,000	5,000
Neutralization No.	0.5	4.3	6.0	6.4	8.5	2.7	7.0	5.8	5.0	5.0
Sludge, percent	0.15	0.20	1.82	3.28	5.54	0.35	1.12	1.60	0.99	0.53
Chloroform Insol., percent	0.08	0.14	1.66	3.01	4.83	0.27	1.01	0.77	0.77	0.41
Viscosity at 210° F., S.S.U.	54.7	66.4	106.2	116.2	161.0	59.6	101.1	104.1	93.2	83.2
Carbon residue, percent	0.41	1.91	4.97	4.9	6.4	0.99	3.91	2.86	2.42	2.11
					*F 5.9					F 1.79
Resin, percent	2.18	13.80	24.06	18.31	16.82	9.32	24.26	18.69	19.31	16.21
Iron as Fe, percent					0.037					0.008
					F 0.032					F 0.006
True Color	41	376	2680	3640	5700	256	940	1730	667	639

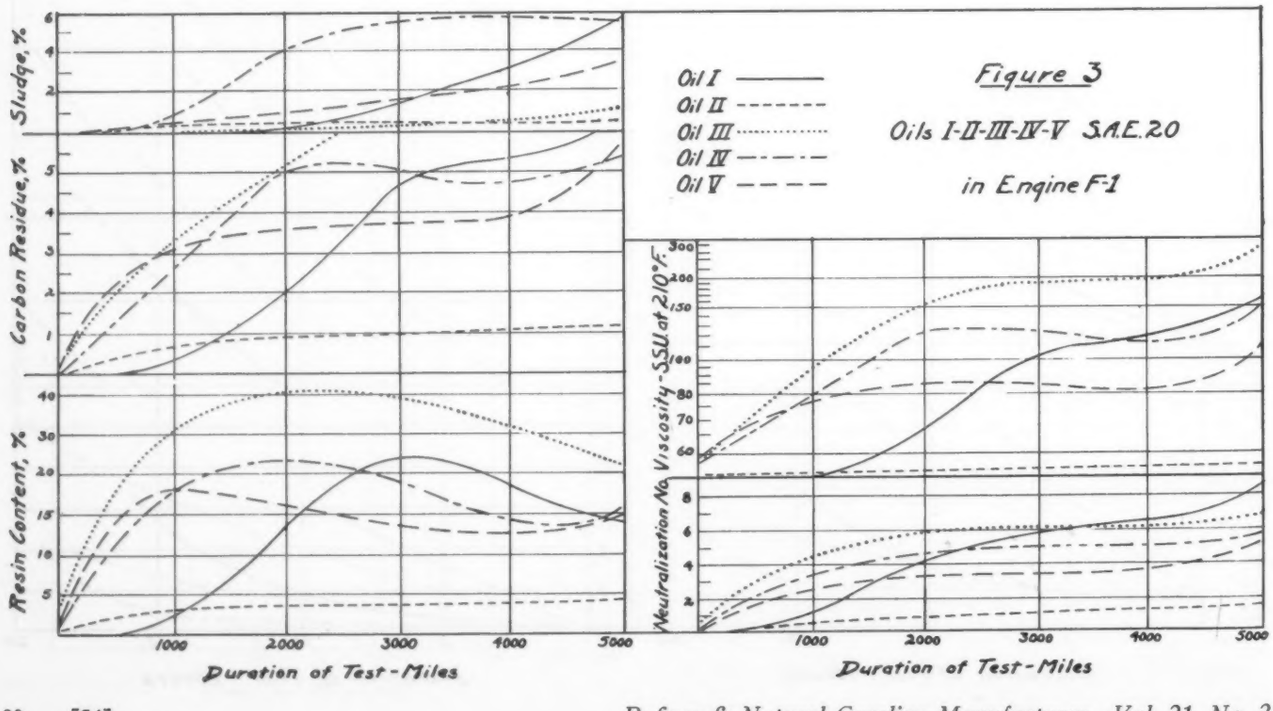
	Group F—Engine No. 2—Oil I					Group H—Engine No. 1—Oil I				
Miles	1,000	2,000	3,000	4,000	5,000	1,000	2,000	3,000	4,000	5,000
Neutralization No.	0.7	6.0	4.2	6.5	4.0	3.5	6.6	6.5	6.5	8.4
Sludge, percent	0.31	1.11	1.38	2.85	2.95	0.40	1.06	2.77	3.42	5.41
Chloroform Insol., percent	0.23	0.96	1.04	2.56	2.35	0.34	0.97	2.62	3.20	5.16
Viscosity at 210° F., S.S.U.	56.4	87.8	77.5	116.0	88.5	61.4	89.3	115.1	104.1	144.8
Carbon residue, percent	0.53	3.42	2.27	4.09	2.8	1.30	3.64	4.67	3.69	4.87
					F 1.05					F 2.18
Resin, percent	2.77	20.81	16.21	18.84	13.02	7.31	20.44	20.49	15.58	18.81
Iron as Fe, percent					0.019					0.053
					F 0.007					F 0.020
True Color	70	846	959	1260	780	179	1205	3280	611	855

	Group G—Engine No. 1—Oil I					Group H—Engine No. 2—Oil I				
Miles	1,000	2,000	3,000	4,000	5,000	1,000	2,000	3,000	4,000	5,000
Neutralization No.	2.2	6.5	6.5	7.0	4.5	1.2	6.1	4.5	6.0	5.5
Sludge, percent	0.50	1.45	1.86	1.60	0.40	0.26	0.29	0.93	1.01	1.20
Chloroform Insol., percent	0.43	1.24	0.21	0.48	0.06	0.21	0.25	0.56	0.84	0.61
Viscosity at 210° F., S.S.U.	58.0	98.8	104.8	109.3	78.5	56.7	76.5	78.0	100.4	96.7
Carbon residue, percent	0.82	3.71	2.9	2.6	1.6	0.67	2.99	2.18	2.69	2.55
					F 1.5					F 2.39
Resin, percent	6.81	22.54	22.82	22.31	16.80	5.13	16.11	16.82	19.93	22.36
Iron as Fe, percent					0.007					0.011
					F 0.006					F 0.010
True Color	186	931	884	799	583	80	667	688	874	752

*F —Sludge free oil.

a uniform high-grade fuel with constant tetraethyl-lead content was used. The loads were maintained constant by fans attached to each engine. The fan-loading device was calibrated to absorb the horsepower required, according to the engine manufacturer's specifications, to drive a sedan of that make at 60 miles per hour. Controlled-forced draft-crankcase ventilation was maintained at the rate specified by the manufacturer of each engine.

Entire engine interiors were thoroughly cleaned and inspected after each run. Before each test, piston rings and bearings were replaced, valves were ground, and the engine brought to new standard condition. A standard oil was used for engine "balancing runs" before the start of the series of tests and periodically during the work to avoid the effects of engine condition "drifting" from standard. The engines usually required only from 2 to 5 quarts additional oil in



5,000 miles, thus indicating minimum oil consumption and "sweetening."

Operating conditions were as follows:

Engine	Group F	Group G	Group H
Load, horsepower	26.5	29	23.5
Speed, r.p.m.	3,040	3,150	2,960
Speed, miles per hour	60	60	60
Oil gallery temperature, degrees F.	280	280	280
Water outlet temperature, degrees F.	185	185	185
Crankcase ventilation, cubic feet per hour	32	26	225
Oil pressure, lbs./sq. in.	11–15	30–35	30–35
Crankcase drains during test	None	None	None
Duration of test, miles nonstop	5,000	5,000	5,000

Road Test Equipment—Engine Groups A, B, C, D

The road test equipment consisted of four each of three different high-production, popular-priced makes of 1940 coupes, designated as groups A, B, and C, and four 1940 trucks equipped with bus axles of 5.22 to 1 ratio, designated as group D. All units complied with stock-engine specifications. A uniform "regular" grade fuel with constant tetraethyl-lead content was used in all units throughout the test.

The road-testing activity occurred during August, 1940, and was conducted over the highly improved roads traversing the desert-like country of a part of

TABLE 5

Average of Products of Change Formed at 1,000, 2,000, 3,000, 4,000, and 5,000 Miles in Oils I, II, III, IV, and V by Tests in Mechanical Laboratory Engines

	Oil I		Oil II		Oil III		Oil IV		Oil V	
		Percent		Percent		Percent		Percent		Percent
GROUP F—ENGINE No. 1										
Neutralization No.	5.1	100	1.1	21	5.2	100	4.8	94	3.7	73
Sludge, percent	2.2	100	0.5	23	0.5	23	5.2	236	1.9	86
Chloroform Insol., percent	1.9	100	0.5	26	0.5	26	0.9	47	1.6	84
Viscosity increase at 210° F. S.S.U.	46.6	100	1.7	4	108.9	234	61.9	135	28.4	61
Carbon residue, percent	3.7	100	0.9	24	5.8	156	4.5	122	3.9	105
Carbon residue Filt.	5.9	100	0.4	7	7.6	128	2.4	41	2.8	48
Resin, percent	15.03	100	4.00	27	26.49	176	17.39	115	14.97	99
Iron-Drain as Fe., percent	0.037	100	0.038	100	0.032	87	0.032	87	0.019	52
Iron-Drain Filt. as Fe., percent	0.032	100	0.010	31	0.030	94	0.010	31	0.004	12
True Color	2287	100	322	14	8494	372	2508	110	2760	122
GROUP F—ENGINE No. 2										
Neutralization No.	4.3	100	3.0	70	4.5	105	4.0	93	4.2	98
Sludge, percent	1.7	100	1.1	65	1.7	100	2.8	165	2.1	124
Chloroform Insol., percent	1.4	100	0.9	64	0.3	21	0.7	50	1.2	86
Viscosity increase at 210° F., S.S.U.	30.8	100	13.9	45	41.1	137	36.4	118	38.7	125
Carbon residue, percent	2.6	100	1.8	69	4.1	157	3.8	146	4.3	166
Carbon residue Filt., percent	1.1	100	1.1	100	3.9	354	0.9	82	3.7	336
Resin, percent	14.33	100	10.66	74	18.03	126	13.77	96	17.86	125
Iron-Drain as Fe., percent	0.019	100	0.014	74	0.018	95	0.028	147	0.025	131
Iron-Drain Filt. as Fe., percent	0.007	100	0.008	114	0.017	242	0.010	143	0.006	86
True Color	783	100	886	115	4353	557	2036	260	3626	463
GROUP G—ENGINE No. 1										
Neutralization No.	5.3	100	2.0	38	5.4	102	3.6	68	3.4	64
Sludge, percent	1.2	100	0.4	33	0.4	33	0.6	50	0.8	67
Chloroform Insol., percent	0.7	100	0.4	57	0.4	57	0.5	71	0.5	72
Viscosity increase at 210° F., S.S.U.	37.5	100	2.4	6	38.9	102	8.3	22	15.9	43
Carbon residue, percent	2.3	100	1.8	78	4.9	212	2.8	123	3.2	138
Carbon residue drain Filt., percent	1.5	100	2.4	160	6.1	407	0.9	60	2.1	140
Resin, percent	18.25	100	6.35	35	22.00	120	6.64	56	10.94	60
Iron-Drain as Fe., percent	0.007	100	0.035	500	0.036	515	0.041	585	0.020	286
Iron-Drain Filt. as Fe., percent	0.006	100	0.031	518	0.025	417	0.024	400	0.010	167
True Color	677	100	1708	252	5416	800	1624	240	2742	406
GROUP G—ENGINE No. 2										
Neutralization No.	5.1	100	4.0	79	3.7	72	3.4	67	2.7	53
Sludge, percent	0.9	100	0.9	100	0.3	33	0.6	67	0.8	89
Chloroform Insol., percent	0.6	100	0.7	117	0.3	50	0.5	82	0.3	50
Viscosity increase at 210° F., S.S.U.	33.8	100	10.3	30	11.2	33	7.2	21	11.0	30
Carbon residue, percent	2.5	100	2.3	92	3.3	132	2.5	100	2.7	108
Carbon residue drain Filt., percent	1.8	100	2.9	162	3.7	206	1.1	61	1.6	89
Resin, percent	17.56	100	9.29	53	10.10	57	7.78	44	8.68	50
Iron-Drain as Fe., percent	0.008	100	0.051	638	0.013	163	0.067	840	0.007	88
Iron-Drain Filt. as Fe., percent	0.006	100	0.036	600	0.011	186	0.051	850	0.004	67
True Color	846	100	1956	232	3386	400	1237	146	2186	259
GROUP H—ENGINE No. 1										
Neutralization No.	6.3	100	4.3	88	6.3	100	4.1	65		
Sludge, percent	2.6	100	1.2	46	0.5	19	2.0	77		
Chloroform Insol., percent	2.5	100	1.1	44	0.5	20	0.6	24		
Viscosity increase at 210° F., S.S.U.	48.5	100	20.5	42	148.1	306	23.9	49		
Carbon residue, percent	3.6	100	2.8	78	6.3	175	2.4	67	Engine H-1 did not complete test due to high oil consumption.	
Carbon residue drain Filt., percent	2.2	100	2.6	117	9.3	425	0.9	41		
Resin, percent	16.53	100	11.69	71	30.48	185	10.34	83		
Iron-Drain as Fe., percent	0.053	100	0.055	104	0.057	108	0.030	57		
Iron-Drain Filt. as Fe., percent	0.020	100	0.042	210	0.050	250	0.013	65		
True Color	1226	100	1597	130	5339	437	605	49		
GROUP H—ENGINE No. 2										
Neutralization No.	4.7	100	5.9	125	10.7	220	4.8	104	5.0	106
Sludge, percent	0.7	100	2.1	300	0.5	71	2.8	400	3.3	470
Chloroform Insol., percent	0.5	100	1.8	360	0.5	100	1.0	200	1.7	340
Viscosity increase at 210° F., S.S.U.	27.3	100	20.9	77	264.6	970	45.8	168	74.1	272
Carbon residue, percent	2.2	100	3.1	140	6.6	300	3.9	177	5.5	250
Carbon residue drain Filt., percent	2.4	100	2.5	104	8.9	370	2.0	83	7.6	312
Resin, percent	16.07	100	15.92	99	39.72	242	17.68	108	19.03	118
Iron-Drain as Fe., percent	0.011	100	0.027	244	0.030	270	0.031	280	0.042	380
Iron-Drain Filt. as Fe., percent	0.010	100	0.019	190	0.033	330	0.016	160	0.037	370
True Color	612	100	1240	203	5346	870	1533	246	5323	870

TABLE 6
Summary of Percentage of Oil Deterioration Products in All Engines Based on Oil No. 1

	Oil I	Oil II	Oil III	Oil IV	Oil V
Neutralization No.	100	70	116	82	79
Sludge, percent	100	94	46	166	167
Chloroform Insol., percent	100	111	46	79	126
Viscosity increase at 210° F., S.S.U.	100	34	297	86	106
Carbon residue, percent	100	80	189	122	153
Carbon residue (drain filt.), percent	100	108	315	61	177
Resin, percent	100	60	151	80	90
True Color	100	154	573	208	424
Average	100	89	216	111	167

Southern Arizona, where high temperatures prevail at that time of year and where traffic conditions permitted continued high-speed operations.

Each day the engines were given a 15-minute "warm-up" as described by Sibley[6] before going on the road. All the test units were operated under a rigid schedule of actual speed, uniformity of speed, and spacing between units.

Two shifts of drivers were used each day. This required 24 drivers for car groups A, B, and C, and 8 drivers for truck group D. The positions of drivers remained constant, and the position of test units moved one position each shift change. By this method each car driver would have the same car every twelfth day. In the same way, each truck driver would have the same truck every fourth day.

Group B is the same make of engine as group F used in the mechanical laboratory engine tests. Group A is very similar in engine design and characteristics to group H of the mechanical laboratory engines.

In addition to the variables of design and materials provided by the mechanical laboratory engines, the road test units included:

1. Engines equipped with three different makes of oil filters supplied as standard engine equipment and engines equipped with no filters.
2. Cast iron and aluminum cylinder heads.
3. Tin-babbitt, copper-lead, and cadmium alloy bearings.
4. In-line and V-type engines.
5. Mechanical and Zero-Lash hydraulic valve filter designs.

Operating conditions were as follows:

UNIT	Group A	Group B	Group C	Group D
Pay load, pounds	Driver plus 250 lbs.	Driver plus 250 lbs.	Driver plus 250 lbs.	Driver plus 13,200 lbs.
Average road speed, m.p.h.	62	62	62	52
Average atmospheric temp., °F.	96	96	96	96
Average oil gallery temp., °F.	198.1	198.3	192.0	157.9
Water outlet temperature, °F.	174.0	171.4	170.5	165.0
Miles traveled per day	578	578	578	492
Break-in miles	2,500	2,500	2,500	2,500
Duration of test	10,080	10,080	10,080	10,086
Miles between drains	2,500	2,500	2,500	2,500

II. Chemical Laboratory and Mechanical Laboratory Investigations

Various engine designs tend to accentuate different types of changes in lubricating oil, and various oils tend to accentuate different types of conditions in an engine. The lubricating oils and engines used in these investigations were developed for general use. To determine the probable changes which might occur in both the oils and engines during a road-test program, investigations were made in special equipment under conditions accelerated to induce these possible changes in the lubricating oils and engine conditions. Determining the nature and degree of the engine and oil changes by chemical laboratory and mechanical laboratory investigations was of untold value in interpreting data obtained from the road tests. Moreover, the confirmation of road test data by chemical and mechanical laboratory data justifies more positive conclusions from road tests.

Some of the characteristics of these oils and these engines determined by chemical and mechanical laboratory investigations include:

(a) Effect of oxygen and metallic accelerators on the oxidation of the oil.
(b) Effect of time, temperature, air, and certain accelerators on corrosion, viscosity increase, asphaltene formation, sludge and resin formation.
(c) Effect of all of the conditions of internal combustion engine operation on the nature of engine dirt, i.e., whether soft and oil suspendable or whether of a hard granular nature which may cause an increased compression ratio with or without abrasion and nature and degree of engine lacquer.

Some of the products of oil change may be more objectionable in certain engine designs and less objectionable in others. For this reason, road testing, to be significant, must include the use of engines which accentuate each of the types of oil and engine changes found objectionable in practical lubrication. These roads tests must be accompanied by laboratory tests designed to accelerate these tendencies to change; therefore, while road tests are indispensable, they are no more infallible than laboratory tests but are the closest approach to service problems.

It has been necessary to condense very greatly the mass of data secured in this testing program both because of lack of space and because of the attempt to present the results in comprehensible form. All of the five oils were tested in the chemical laboratory and on all of the groups of mechanical laboratory engines, but the number of road test units involved prevented testing all the oils in all groups of road test units.

The percentage of change in each oil on each test has been calculated, calling Oil I the reference oil and rating its changes as 100 percent. In all comparisons, a higher percentage represents a larger amount of change in the oil or engine condition and a lower percentage a lesser amount.

The average percentage change based on Oil I for each oil and type of testing equipment is simply an unweighted average of all the types of change noted. It is realized that differences of opinion exist as to the relative importance of the various types of change in both oil and engine condition in service, and no attempt has been made to give each type the correct weight. Accordingly, the averages shown will not necessarily represent the ratings which everyone would agree to as a proper evaluation of the oil. The data show that changes occurred, and it is assumed that all change is equally undesirable.

Oxygen Absorption

The results of the oxygen absorption test described by Davis et al[5] are shown in Table 2 and Figure 1. The "stability" shown is the time in minutes re-

TABLE 7
Summary of Percentage of Oil Deterioration in Each Engine Based on Oil No. 1

	Oil I	Oil II	Oil III	Oil IV	Oil V
Group F, Engine 1	100	19	152	112	85
Group F, Engine 2	100	75	195	126	190
Group G, Engine 1	100	82	228	84	124
Group G, Engine 2	100	108	123	74	91
Group H, Engine 1	100	77	208	72	x
Group H, Engine 2	100	176	393	173	342
Average	100	89	213	107	166

quired for the oil, without metal-containing catalyst, to absorb sufficient oxygen to cause a drop in pressure of 60 mm. The "iron tolerance" shown is the amount of iron naphthenate in "percent Fe_2O_3" required by each oil to produce a perceptible acceleration in the rate of oxygen absorption. The reciprocal of these percentages of iron oxide measures the sensitivity of the oils to catalytic oxidation. This tendency is shown in Table 2 in percentage for each of the five oils with Oil I arbitrarily given a rating of "100 percent."

The oxygen-absorption test gives no information of the type of oil deterioration products that might be expected in engine service. It indicates only the relative tendency of oils to form oxidation products which may remain in solution or in suspension in the oil or be deposited on engine surfaces. From this table, the amount of oxidation products formed in Oil II and Oil I would be expected to be quite similar under all conditions of service. Oil III should form less oxidation products than Oils I and II in the absence of oxidation accelerators, such as dissolved metal compounds. It is, however, indicated to be more sensitive than Oil I to the catalytic effect of metal compounds which are always encountered in automotive service.

Oil IV is indicated to possess a high inherent stability to straight oxidation but to be more affected by catalysts than Oil I. Of the entire group, Oil V is the least stable and most sensitive to catalysts and would be expected to permit the formation of the largest amounts of oxidation products. This test rates the sensitivity of the oils to catalytic oxidation in the order of descending merit as: 1, 2, 4, 3, and 5.

Figure No. 4 — ENGINE RATING SHEET — Date 7-4-40, Run No. 44

Engine Make and No.		Group F-No. 1			Engine Deposits			
Date Started		6-26-40			Location			Rating
Date Completed		7-1-40			Valve Gallery			20 SL
Oil Used		Oil No. 1			Crank Shaft			25 CL
Miles Break-In		500			Engine Interior			25 SL
Miles on Test		5000			Oil Pan			20SLC
Speed - M.P.H.		60 avg.			Oil Pump Screen			10 C
Load - H.P.		26 avg.			Piston Skirt			15 L
Water Outlet Temp. °F.		185°			Piston Under Head			10 C
					Piston Head			30C Lead
					Cyl. Below Ring Travel			20 L
		Start	Finish	Avg.	Valve Deck			35C Lead
Oil Gallery Temp. °F.		270	283	279	Valve Stem			20 CL
Oil Pressure		14	15	14.8	Connecting Rod Bearings			35 L
OIL ADDED					Piston Ring Grooves			20 C
Miles	Amount	Miles	Amount	Miles	Amount	Connecting Rods		15 L
3212	1 qt.					Wrist Pins		10 L
						Cylinder Head		30C Lead
						Engine Average		21
						Stuck Rings in Tenths		0

Sample Miles	1000	2000	3000	4000	Drain 5000
Sludge % by Wt.	0.15	0.20	1.82	3.28	5.54
N.N. Sludge Present	0.5	4.3	6.0	6.4	8.5
C.R. Sludge Present	0.41	1.91	4.97	4.90	6.40
Vis. @ 210°F. Sludge Present	54.7	66.4	106.2	116.2	161.0
Resin Per Cent	2.18	13.80	24.06	18.31	16.82

See reverse side for general remarks.

Engine deposits C,L,S, stand for carbon, lacquer, and sludge respectively. Under ratings the lower numerical value indicates the cleanest engine, ratings are made from 0 to 100.

FIGURE 4

Modified Underwood

The results of tests in an all steel modified Underwood apparatus[7] at 350° F. using 15 square inches of sheet lead in the heater chamber are shown in Table 3 and Figure 2.

The results of the modified Underwood test are shown as time in hours required to produce an arbitary amount of each of the products of oil change. The reciprocals of these time periods are a measure of the rate of formation of each of these products. These rates of formation of each of these products by the five oils are shown in percentages.

Both cadmium - silver and copper - lead bearings were used, and this test indicates fairly well the relative corrosiveness of oils in engines using these bearings. No oil-soluble metallic catalysts are added to the oil in this test. A time period is required for the formation of oxidation products. The length of this time period is fixed by the stability of the oil to oxidation, but not by its sensitivity to the effect of added catalysts. When corrosive oxidation products are formed, they will corrode the bearing metals, iron of the Underwood parts, and the lead sheet, thus forming soluble metal-containing compounds. All of these metal-containing compounds greatly accelerate the rate of oxidation and accordingly the rate of formation of all of the various types of oxidation products. The ratio of the amounts of these various types of oxidation products depends on the nature of the oil; therefore the time required for the formation of a given total amount of oxidation products is measured by the time required for the oil to become corrosive. Some information concerning the predominating type of products of oil change which may be expected in automotive service is obtained. The modified Underwood rates the SAE 20 oils in the order of descending merit as: 4, 1, 2, 5, and 3; and the SAE 30 grade as: 4, 2, 1, 3, and 5. It is interesting to note that this test rates these five oils roughly in the same order as does the oxygen-absorption test.

Engine Stands

Results of tests of these oils on one of the Group F engines are shown graphically in Figure 3. The SAE 20 grades were used in these tests. The engines

TABLE 8
Engine Cleanliness

Engine	OIL I		OIL II		OIL III		OIL IV		OIL V	
	Engine Average	Percent	Engine Average	Percent	Engine Average	Percent	Engine Average	Percent	Engine Average	Percent
F-1	21	100	14	67	14	67	28	133	30	143
F-2	27	100	19	71	14	52	26	97	27	100
G-1	55	100	19	35	16	29	21	38	24	44
G-2	57	100	19	33	18	32	20	35	25	44
H-1	27	100	15	55	13	49	23	85	x	x
H-2	49	100	25	51	15	31	37	75	33	67
Average		100		52		43		77		80

TABLE 9

Location of important engine deposits as taken from engine rating sheets.

Engine	Location	Oil I	Oil II	Oil III	Oil IV	Oil V
F-1	Valve gallery	20	15	15	35	25
	Engine interior	25	15	15	35	25
	Oil pan	20	20	25	30	30
	Oil screen	10	0	0	25	5
	Piston skirt	15	5	5	25	45
	Ring grooves	20	20	25	25	70
	Valve stem	20	10	10	10	20
F-2	Valve gallery	25	10	15	35	25
	Engine interior	20	15	15	30	25
	Oil pan	40	25	25	30	25
	Oil screen	40	0	5	10	15
	Piston shirt	25	15	5	25	30
	Ring grooves	30	25	30	35	70
	Valve stem	25	10	10	15	15
G-1	Valve gallery	55	25	10	20	20
	Engine interior	65	25	10	20	25
	Oil pan	75	25	20	20	25
	Oil screen	95	0	5	0	5
	Piston skirt	55	35	20	25	30
	Ring groove	85	25	35	35	40
	Valve stem	80	10	5	15	20
G-2	Valve gallery	60	20	20	20	25
	Engine interior	65	20	20	15	25
	Oil pan	75	15	15	20	35
	Oil screen	95	0	0	0	10
	Piston skirt	60	35	20	25	30
	Ring groove	85	35	35	30	35
	Valve stem	85	5	10	10	25
H-1	Valve gallery	45	30	20	30	Did
	Engine interior	30	15	15	25	not
	Oil pan	25	10	15	20	finish
	Oil screen	25	0	0	0	test
	Piston skirt	15	5	5	20	
	Ring groove	35	10	5	35	
	Valve stem	50	5	15	15	
H-2	Valve gallery	80	45	20	55	45
	Engine interior	70	30	20	50	35
	Oil pan	45	20	20	50	25
	Oil screen	95	45	5	30	30
	Piston skirt	20	5	5	20	10
	Ring groove	75	45	20	70	70
	Valve stem	65	5	10	15	30

operated on stand tests required an SAE 20, and the road tests called for an SAE 30; therefore the grade of oil most suitable to each type of equipment was used. Use of two SAE grades also permits observation of constancy of performance characteristics.

Table 4 shows the results of examination of used-oil samples from tests of Oil I on these 6 engines. This table will show the rate of formation of the various deterioration products during the test of this one oil on each engine. Only the average amounts of each of the deterioration products found in the 5 samples taken at 1000, 2000, 3000, 4000, and 5000 miles for each of the 5 oils tested in each of the 6 engines are shown in Table 5. All the test data on Oil I are given an arbitrary rating at 100 percent, and then the degree of change in each respect with the other oils is shown as a percentage of the change in Oil I.

Table 6 lists an average of all of the different percentages for each oil on all six of the test engines. Iron content percentages were not included in this summary, since extremely small amounts of iron resulted in a large difference in percentage for the various oils and seemed misleading.

From Table 6, we find the tendency of Oils IV and V to form oil insoluble products with high carbon residue and to become highly colored, and Table 8 also shows these oils formed rather heavy engine deposits in all three engine groups, especially in engine group F.

Table 6 indicates that Oil III forms oil-soluble products resulting in great increases in oil viscosity, high carbon residue of the sludge-free oil, and marked oil discoloration. Comparison with Table 8 shows Oil III resulted in the cleanest engine interior and the dirtiest oils, suggesting excellent detergent properties at the expense of fluidity and stability. Engines H-1 and H-2 produced with Oil III an average viscosity increase from an original of 55 S.S.U. at 210° F. to 203 and 319 S.S.U. at 210° F. respectively, with final viscosities nearly double the averages, while engine groups F and G produced less severe increases.

The average of the deterioration products from all engines determined by examination of the used oils

TABLE 10

Products of Change in Oil II in Each Oil Drain from Road Tests

	GROUP A—ENGINE No. 3					GROUP B—ENGINE No. 3				
Drain	1	2	3	4	Average	1	2	3	4	Average
Miles	2,592	2.304	2,304	2,880	2,520	2,592	2,304	2,304	2,880	2,520
Neutralization No	1.05	0.22	0.15	0.20	0.41	8.5	1.4	1.2	1.4	3.1
Sludge, percent	1.11	0.16	0.12	0.09	0.37	1.48	1.31	1.58	1.85	1.56
Chloroform Insol., percent	0.93	0.07	0.08	0.05	0.28	1.01	0.56	1.29	1.69	1.14
New Oil viscosity at 210° F	60.4	60.4	60.4	60.4	60.4	60.4	60.4	60.4	60.4	60.4
Drain viscosity at 210° F	59.8	60.0	59.4	60.2	59.9	89.0	61.0	61.0	60.6	67.9
Carbon residue, percent	1.08	0.085	0.086	0.13	0.345	3.95	1.88	1.71	2.34	2.49
Carbon residue filtered, percent	0.58	0.074	0.042	0.06	0.189	3.24	1.03	0.28	1.25	1.45
Resin, percent	1.19	1.22	1.11	0.81	1.08	17.28	3.20	1.68	1.22	5.85
Iron as Fe, percent	0.036	0.002	0.001	0.002	0.010	0.030	0.009	0.009	0.008	0.014
Iron as Fe filtered, percent	0.013	0.002	0.001	0.001	0.004	0.024	0.006	0.002	0.006	0.010
Lead as Pb, percent	0.129	0.021	None	0.04	0.17	0.649	0.920	0.706	1.28	0.89
True Color	179	42	41	46	77	1460	256	91	120	482
Dilution, percent	1.2	1.6	0.8	1.6	1.3	2.4	2.0	1.0	1.6	1.8
Water, percent	None	None	Trace	None	None	None	None	Trace	None	None
Flash, °F	430	380	390	350	388	400	405	380	370	389

	GROUP C—ENGINE No. 3					GROUP D—ENGINE No. 2				
Drain	1	2	3	4	Average	1	2	3	4	Average
Miles	2,592	2,304	2,304	2,880	2,520	2,706	2,460	2,460	2,460	2,522
Neutralization No	5.0	0.5	0.4	0.4	1.6	0.2	0.2	0.4	0.25	0.26
Sludge, percent	0.20	0.27	0.14	0.08	0.17	0.15	0.09	0.12	0.05	0.10
Chloroform Insol., percent	0.11	0.11	0.06	0.01	0.07	0.07	0.05	0.04	0.02	0.05
New Oil viscosity at 210° F	60.4	60.4	60.4	60.4	60.4	60.4	60.4	60.4	60.4	60.4
Drain viscosity at 210° F	70.2	60.6	59.8	61.0	62.9	55.6	57.0	55.8	56.4	56.2
Carbon residue, percent	2.31	0.38	0.18	0.18	0.76	0.086	0.077	0.07	0.07	0.076
Carbon residue filtered, percent	2.20	0.21	0.14	0.12	0.67	0.067	0.066	0.062	0.05	0.061
Resin, percent	10.30	2.29	1.72	1.33	3.91	0.88	0.89	0.87	1.02	0.92
Iron as Fe, percent	0.010	0.004	0.003	0.001	0.005	0.001	0.002	0.002	0.004	0.002
Iron as Fe filtered, percent	0.012	0.002	0.003	0.001	0.005	0.001	0.002	0.002	0.004	0.002
Lead as Pb, percent	0.617	0.106	0.07	0.07	0.23	0.006	0.005	0.01	0.02	0.01
True Color	346	76	69	91	146	30	32	24	32	30
Dilution, percent	1.8	3.2	1.8	1.2	2.0	3.0	2.0	3.8	2.8	2.9
Water, percent	None	None	None	None	None	None	None	Trace	None	None
Flash, °F	350	330	340	335	339	270	230	260	255	254

as shown in Table 6 rates the oils in decreasing order as 2, 1, 4, 5, and 3.

Table 7 shows the average for all the deterioration products for each oil as measured by each engine based on the percentage change below or above Oil I, and these data also rate the oils in descending order of merit as 2, 1, 4, 5, and 3.

Table 8 shows the numerical engine cleanliness rating of each engine operated with each oil and the percentage comparison of the 5 oils. The engines were rated at the end of each test run by an experienced engineer using retained engine parts as standards. These ratings are made on the scale of 0 to 100 with a clean part being rated as 0 and one sufficiently dirty to make operation impossible being rated as 100. A typical engine inspection sheet is shown in Figure 4. From these inspection sheets, the engine average for each engine after operating with each of the five oils is shown and compared on a percentage basis.

Engine group G rates Oil I materially worse than do groups F and H, but all engines show that Oil I produced considerable engine deposit. All three engine groups show that Oils II and III are quite free of deposit characteristics and that Oils IV and V produce moderately heavy deposits. The data reveal the importance of using several engine designs in evaluating oils in service, since one type of engine can rate oils in materially different order than the average of three types of engines.

Table 9 shows a detail of the numerical ratings obtained on the more important engine parts with respect to the manner in which individual engines affected each oil. An oil that showed heavy skirt deposits on one type piston showed moderate to light deposits on a different type piston. Oils that one valve design rates as objectionable, another valve design will rate acceptable.

From the standpoint of engine cleanliness alone (Table 8), the engines rate the oils from best to poorest as 3, 2, 4, 5, and 1.

Comparison of data from Tables 6, 7, and 8 shows Oil III producing the cleanest engines and the dirtiest used oils, indicating good detergency at the expense of oil stability. Oil I produced the dirtiest engines but rated second in oil cleanliness condition, indicating relatively good oil stability but relatively poor detergency. The other three oils are indicated to possess better balanced performance properties with Oil II showing the best stability and second best engine cleanliness, Oils IV and V following in order.

Giving due consideration to the equally important factors of oil stability and engine interior cleanliness, we find from Tables 6 and 8:

	Oil I	Oil II	Oil III	Oil IV	Oil V
Table 6—Oil Condition	100	89	216	111	167
Table 8—Engine Condition	100	55	47	78	80
Average	100	72	132	94	124

Thus the mechanical laboratory engines show that the rating of the five oils from best to poorest is: 2, 4, 1, 5, and 3.

III. Road Tests

The results of examination of the used oil from each of the four drains from all road tests using Oil II are listed in Table 10. In order to permit comparison of the various oils with the elimination of engine

TABLE 11

Average amounts and comparative percentages of products of change in oils in road tests—2520 miles.

GROUP A

	OIL I		OIL II		OIL V	
		Percent		Percent		Percent
Neutralization No.	0.31	100	0.41	132	2.3	740
Sludge, percent	0.27	100	0.37	137	0.43	158
Chloroform Insol., percent	0.19	100	0.28	147	0.27	142
New oil viscosity at 210° F., S.S.U.	60.7		60.4		60.5	
Drained oil viscosity at 210° F., S.S.U.	60.3	100	59.9	91	70.3	254
Carbon residue, percent	0.201	100	0.095	47	2.15	1070
Carbon residue, filt., percent	0.057	100	0.189	332	1.85	3240
Resin, percent	1.46	100	1.08	74	7.29	500
Iron as Fe, percent	0.004		0.010		0.053	
Iron as Fe filt., percent	0.002		0.004		0.027	
Lead as Pb, percent	0.20		0.17		0.51	
True color	42	100	77	187	752	1780
Dilution, percent	1.8		1.3		1.8	
Water, percent	00		00		00	
Flash, °F	410		388		408	
Average		100		143		985

GROUP B

	OIL I		OIL II		OIL III	
		Percent		Percent		Percent
Neutralization No.	8.7	100	3.1	36	7.3	94
Sludge, percent	2.13	100	1.56	78	0.79	37
Chloroform insol., percent	0.53	100	1.14	208	0.46	87
New oil viscosity at 210° F., S.S.U.	60.7		60.4		67.9	
Drained oil viscosity at 210° F., S.S.U.	85.6	100	67.9	44	110.6	156
Carbon residue, percent	3.25	100	2.47	76	4.44	136
Carbon residue, filt., percent	2.05	100	1.45	71	4.02	196
Resin, percent	14.25	100	5.85	41	18.40	130
Iron as Fe, percent	0.031		0.014		0.017	
Iron as Fe, filt., percent	0.012		0.010		0.013	
Lead as Pb., percent	0.92		0.89		0.93	
True color	429	100	482	112	1965	457
Dilution, percent	1.9		1.8		2.5	
Water, percent	00		00		00	
Flash, °F	366		389		380	
Average		100		83		162

GROUP C

	OIL I		OIL II		OIL IV	
		Percent		Percent		Percent
Neutralization No.	1.0	100	1.6	160	1.7	170
Sludge, percent	0.12	100	0.17	142	0.14	117
Chloroform Insol., percent	0.06	100	0.07	117	0.09	150
New oil viscosity at 210° F., S.S.U.	60.7		60.4		62.0	
Drained oil viscosity at 210° F., S.S.U.	61.1	100	62.9	121	67.5	169
Carbon residue, percent	0.49	100	0.76	155	1.32	270
Carbon residue filt., percent	0.42	100	0.67	159	1.13	270
Resin, percent	3.39	100	3.91	115	5.72	169
Iron as Fe, percent	0.005		0.005		0.006	
Iron as Fe filt., percent	0.003		0.005		0.005	
Lead as Pb., percent	0.13		0.23		0.33	
True color	103	100	146	142	225	209
Dilution, percent	1.3		2.0		1.6	
Water, percent	00		00		00	
Flash, °F	318		339		353	
Average		100		139		191

GROUP D

2522 miles

	OIL I		OIL II		OIL III		OIL IV	
		Percent		Percent		Percent		Percent
Neutralization No.	0.3	100	0.26	87	3.4	1,113	3.12	1,080
Sludge, percent	0.11	100	0.10	91	0.22	200	0.18	164
Chloroform, Insol., percent	0.07	100	0.05	71	0.12	172	0.09	128
New oil viscosity at 210° F., S.S.U.	60.7		60.4		67.9		62.0	
Drained oil vis. at 210° F., S.S.U.	56.2	100	56.2	92	70.6	388	63.2	326
Carbon residue, percent	0.081	100	0.061	94	2.42	2,980	1.83	2,260
Carbon residue filt., percent	0.057	100	0.061	107	2.30	4,040	1.42	2,500
Resin, percent	1.27	100	0.92	72	7.45	590	6.63	523
Iron as Fe, percent	0.002		0.002		0.006		0.008	
Iron as Fe, filt., percent	0.002		0.002		0.005		0.004	
Lead as Pb, percent	0.11		0.01		0.65		0.45	
True color	32	100	30	94	441	1,375	169	530
Dilution, percent	2.8		2.9		2.8		2.9	
Water, percent	00		00		00		00	
Flash, °F	254		254		248		271	
Average		100		77		1,357		939

differences, the average amount of deterioration products and comparison on a percentage basis in each group of test equipment are shown in Table 11. The lubricating oil dilution in all of these engine tests was found to be approximately 2 percent. It has been determined that 2 percent dilution reduces the fresh oil Saybolt Universal Viscosity at 210° F. about 7 seconds. Accordingly, 7 seconds were deducted from the viscosity at 210° F. of the unused oils, and the resulting viscosity used in calculating viscosity increase.

Table 12 shows the engine ratings of each engine group, fuel, and oil consumption rates with the various oils. The compression ring wear figures are shown, as they are of sufficient magnitude to indicate a trend with reasonable reliability. Wear of other parts was so small that the first significant figures range from the fourth to the sixth decimal place, and their inclusion might be misleading. Inclusion or exclusion of the wear data, however, does not alter the results because they are not in conflict with the other results. Engine ratings shown were obtained by the same procedure as previously described for the mechanical laboratory engines.

Because of the unavoidable differences between mechanical laboratory engine tests and road tests, the possibility of making an equitable or acceptable numerical comparison of the results is questioned. The laboratory engines were run 5000 miles without a drain, samples for progressive oil condition change were secured at 1000-mile intervals, providing data for curves, and all engines were thoroughly cleaned between runs. The road engines were drained approximately every 2500 miles, and some oil deterioration products were unavoidably left in the engines to contaminate, to some degree, the succeeding oil change; and since samples were taken only at drain periods, final oil condition characteristics only are available. All mechanical laboratory engine tests were made without the use of oil filters. Standard factory equipment oil filters of three different makes were used on engines of road groups A, C, and D, while Group B units were not equipped with filters. Laboratory engines were required to complete 5000 miles of continuous operation while road units were operated during the day only.

Table 13, however, gives a summary of the more important oil changes for all tests, and Table 14 gives a summary of all engine ratings.

An examination of the data on Tables 10, 11, 12, and 13, however, shows the same general oil behavior characteristics; and Table 14 discloses the same engine condition characteristics of the five oils as were indicated from the oxygen absorption, modified Underwood, and the mechanical laboratory engine tests previously discussed, viz.:

Oil I shows the same relatively good oil stability characteristics as evidenced by low neutralization number, low sludge, low chloroform insolubles, low viscosity increase, low discoloration, and low resin and its lack of detergent properties by high engine condition ratings or engine dirt.

Oil III shows the same relatively high neutralization number, very low sludge and chloroform insolubles, but high viscosity increase with high discoloration, high carbon, and high resin content indicating good peptizing or detergency characteristics at the expense of stability as previously indicated on Tables 6, 7, and 8. These characteristics are more pronounced in engine group B, where oil temperatures were higher than in engine group D. The engine inspections showed relatively good freedom from sludge but considerable resinous deposits, particularly in the hydraulic valve lifters of engine group D where 9 of the 12 lifters were stuck with lacquer.

Oil IV displayed more balanced stability and engine dirt characteristics than Oils I and III, having moderate neutralization number increase, low sludge, low chloroform insolubles, low discoloration, and moderately low carbon residue but high resin content. This oil condition was evidenced by having 11 out of 12 hydraulic valve lifters stuck with resinous deposits.

Oil V is indicated as developing high neutralization number, moderately low sludge, and chloroform insolubles, but having tendencies to increase considerably in viscosity and darken in color with high carbon residue and moderately high resin. Oil V formed sufficient hard carbon on the land above the upper compression rings to act as an abrasive. This probably was the cause of the exceedingly high increase in piston ring gaps which in turn promoted high oil consumption. The car using Oil V detonated badly during acceleration, indicating increased compression ratio due to carbon deposits.

Oil II again shows to advantage with low neutralization number, low sludge, low chloroform in-

TABLE 12

Engine cleanliness, corrosion, wear, and fuel and oil consumption in road tests.

GROUP A

	OIL I		OIL II		OIL V	
		Percent		Percent		Percent
Engine rating	16.9	100	13.2	78	15.8	93
Bearing corrosion	No		No		Trace	
Compression ring—gap increase	.0066	100	.0072	109	.0537	814
Oil used—quarts per 1,000 miles	1.1	100	1.8	167	3.3	300
Gasoline used—gallons per 1,000 miles	57	100	56	98	56	98
Average		100		113		426

GROUP B

	OIL I		OIL II		OIL III	
		Percent		Percent		Percent
Engine rating	23.7	100	14.2	60	19.1	81
Bearing corrosion	No		No		No	
Compression ring—gap increase	.0086	100	.0052	60	.0054	63
Oil used—quarts per 1,000 miles	1.0	100	0.85	85	1.4	40
Gasoline used—gallons per 1,000 miles	62	100	59	95	63	102
Average		100		75		96

GROUP C

	OIL I		OIL II		OIL IV	
		Percent		Percent		Percent
Engine rating	18.9	100	14.9	79	16.7	88
Bearing corrosion	Light		Trace		Trace	
Compression ring—gap increase	.0129	100	.0053	41	.0054	42
Oil used—quarts per 1,000 miles	2.6	100	2.0	78	2.1	83
Gasoline used—gallons per 1,000 miles	52	100	53	101	54	102
Average		100		75		79

GROUP D

	OIL I		OIL II		OIL III		OIL IV	
		Percent		Percent		Percent		Percent
Engine rating	10.7	100	7.3	68	15.1	141	17.1	160
Bearing corrosion	No		No		Yes		Yes	
Zero-Lash valve lifters stuck	3		1		9		11	
Compression ring-gap increase	.0048	100	.0048	100	.0056	117	.0054	113
Oil used—quarts per 1,000 miles	.49	100	.41	84	.44	90	.47	96
Gasoline used—gallons per 1,000 miles	103	100	101	98	106	103	104	101
Average		100		87		113		118

solubles, low viscosity increase, low discoloration, and low carbon residue and low resin; and the engine inspections showed the best ratings of all oils tested.

The effect of increased viscosity of Oils III, IV, and V as a result of oil-soluble contaminating materials is interesting, as evidenced by poorer fuel economy and generally increased oil consumption indicating less effective ring action. Lacquer deposition is noted with Oils III and IV, especially in the hydraulic valve lifters, indicating that these oils had approached or just passed the critical point and that resins were dropped out of solution. This suggests the probability that the oil soluble metallic catalysts left in the engines at the drain periods were sufficient to accelerate oil decomposition and the resultant deposition. This probably accounts for greater oil punishment by road test units than by the engine stands as observed by Sibley et al,[6] in spite of lower operating temperatures of road test units.

TABLE 13

Summary of percentage—Comparison of oil change.

INCREASE IN NEUTRALIZATION NUMBER

Test Equipment	Grade SAE No.	Oil I	Oil II	Oil III	Oil IV	Oil V
Modified Underwood	20	100	117	141	77	128
Modified Underwood	30	100	71	150	67	240
Engine F-1	20	100	21	100	94	73
Engine F-2	20	100	70	105	93	98
Engine G-1	20	100	38	102	68	64
Engine G-2	20	100	79	72	67	53
Engine H-1	20	100	88	100	65	..
Engine H-2	20	100	125	220	104	106
Road Group A	30	100	132	....	....	740
Road Group B	30	100	36	94	....	....
Road Group C	30	100	160	....	170	....
Road Group D	30	100	87	1113	1080	....
FORMATION OF SLUDGE						
Modified Underwood	20	100	134	68	81	134
Modified Underwood	30	100	91	100	76	76
Engine F-1	20	100	23	23	236	86
Engine F-2	20	100	65	100	165	124
Engine G-1	20	100	33	33	50	67
Engine G-2	20	100	100	33	67	89
Engine H-1	20	100	46	19	77	....
Engine H-2	20	100	300	71	400	470
Road Group A	30	100	137	....	....	158
Road Group B	30	100	78	37	....	....
Road Group C	30	100	142	....	117	....
Road Group D	30	100	91	200	164	....
INCREASE IN VISCOSITY AT 210° F., S.S.U.						
Modified Underwood	20	100	108	176	77	141
Modified Underwood	30	100	86	200	67	300
Engine F-1	20	100	4	234	135	61
Engine F-2	20	100	45	137	118	125
Engine G-1	20	100	6	102	22	43
Engine G-2	20	100	30	33	21	30
Engine H-1	20	100	42	306	49	....
Engine H-2	20	100	77	970	168	272
Road Group A	30	100	91	....	....	254
Road Group B	30	100	44	156	....	....
Road Group C	30	100	121	....	169	....
Road Group D	30	100	92	388	326	....
CONRADSON CARBON RESIDUE						
Modified Underwood	20	100	106	166	79	136
Modified Underwood	30	100	100	130	69	322
Engine F-1	20	100	24	156	122	105
Engine F-2	20	100	69	157	146	166
Engine G-1	20	100	78	212	123	138
Engine G-2	20	100	92	132	100	108
Engine H-1	20	100	78	175	67	....
Engine H-2	20	100	140	300	177	250
Road Group A	30	100	47	....	....	107
Road Group B	30	100	76	136	....	....
Road Group C	30	100	155	....	270	....
Road Group D	30	100	94	2980	2260	....
FORMATION OF RESIN						
Modified Underwood	20	100	109	151	67	109
Modified Underwood	30	100	90	180	50	450
Engine F-1	20	100	27	176	115	99
Engine F-2	20	100	74	126	96	125
Engine G-1	20	100	35	120	56	60
Engine G-2	20	100	53	57	44	50
Engine H-1	20	100	71	185	83	....
Engine H-2	20	100	99	242	108	118
Road Group A	30	100	74	....	....	500
Road Group B	30	100	41	130	....	....
Road Group C	30	100	115	....	169	....
Road Group D	30	100	72	590	523	....
FORMATION OF COLOR						
Engine F-1	20	100	14	372	110	122
Engine F-2	20	100	115	557	260	463
Engine G-1	20	100	252	800	240	406
Engine G-2	20	100	232	400	146	259
Engine H-1	20	100	130	437	49	....
Engine H-2	20	100	203	870	246	870
Road Group A	30	100	187	....	....	1780
Road Group B	30	100	112	457	....	....
Road Group C	30	100	142	....	209	....
Road Group D	30	100	94	1375	530	....

Each of the more significant oil characteristics as shown in Table 11 have been evaluated, listing the oils in order of descending merit with respect to each characteristic. This study rates the oils as follows:

Neutralization Number	2	1	3–4		5
Sludge, percent	1	2	3	4	5
Viscosity (drained oil)	2	1	4	3	5
Carbon residue, percent	2	1	5	4	3
Resin, percent	2	1	3–4		5
True Color	1	2	4	3	5
Oil—order descending merit	2	1	4	3	5

In the same manner, from Table 12, the major factors of engine condition during and after test have been rated individually and show:

Engine	2	3	5	1	4
Bearing corrosion	2–1		3–4		5
Comp. ring gap wear	2	1	4	3	5
Oil consumption	2	1	3	4	5
Gasoline consumption	2	5	1	4	3
Engine—order descending merit	2	1	3	4	5

Giving equal consideration to oil stability and engine condition, we find the order of descending merit to be:

Oil stability	2	1	4	3	5
Engine condition	2	1	3	4	5
Over-all order descending merit	2	1	3–4 4–3		5

Conclusion

Thus, the oxygen absorption test, modified Underwood test, mechanical laboratory engine, and road test units rate the five oils in order of descending merit as:

Oxygen-absorption test	1	2	4	3	5
Modified Underwood test—SAE 20	4	1	2	5	3
Modified Underwood test—SAE 30	4	2	1	3	5
Mechanical laboratory engines—SAE 20	2	4	1	5	3
Road-test engines—SAE 30	2	1	3–4 4–3		5

From the study of these five oils, considering both the nature and degree of oil change and engine con-

TABLE 14

Summary of engine rating sheet.

Test Equipment	Grade SAE No.	Oil I	Oil II	Oil III	Oil IV	Oil V
Engine F-1	20	100	87	87	136	146
Engine F-2	20	100	71	52	97	100
Engine G-1	20	100	35	29	38	44
Engine G-2	20	100	33	32	35	44
Engine H-1	20	100	55	49	85	
Engine H-2	20	100	51	31	75	67
Road Group A	30	100	78			93
Road Group B	30	100	60	81		
Road Group C	30	100	79		88	
Road Group D	30	100	68	141	160	

ditions, the data indicate Oil II should give outstandingly good results in commercial use. The accuracy of this indication has been adequately proved by substantially a year's commercialization of the lubricant.

The mass of data accumulated and an analysis of the over-all picture of results certainly indicate there is still considerable room for debate as to the optimum degree of peptizing or detergency desired in an oil. The minimum change in oil characteristics in service is most imperative along with enough peptizing to prevent excessive deposition of materials of either intrinsic or extrinsic origin. The evidence certainly indicates the desirability of preventing the formation of products of oil change rather than permitting their formation and causing them to be dissolved in the oil, since such oil-soluble products result in accelerated rates of oil change due to their catalytic effect.

Since it has been shown that the road-test units displayed higher rates of oil change even though they had lower operating temperatures, it appears that the catalytic effect of oil-deterioration residues left in the engines at oil-change periods is of greater magnitude than is generally recognized; and it is doubtful if increased engine-stand oil temperature can be satisfactorily substituted for this effect.

It is recognized that engine-stand operations should always start with a scrupulously clean engine to avoid the "poisoning" effect of residues on the next oil tested. Otherwise, the observed results are almost invariably misleading. The work indicates the desirability of consideration of this factor in engine-stand tests.

This series of tests indicates the indispensability of a variety of equipment in oil testing and the futility of hope that a single piece of equipment may be developed which will quickly and correctly evaluate lubricating oils. This is further shown by the fact that even this comprehensive series of tests failed to provide the opportunity to confirm or refute the indicated corrosive tendency of the SAE 30 grade of Oil V shown by the modified Underwood test in Table 3.

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Welding Grooves

[*Continued from page 78*]

any good welder to accomplish the desired degree of quality. Single bevel butt welds should not be selected when the root is subjected to tension bending. Any slight lack of fusion might become aggravated into an alarming crack.

Double-butt welds require approximately half as much weld metal as single-butt welds. This attribute of the double-butt weld has contributed much to its popularity among designers and welding supervisors. The principal thing to watch with double-butt welds is the chipping to assure the joining of the weld metal applied from the second side to that already deposited on the first side. And this chipping should be wide enough to allow plenty of room for the satisfactory application of the first beads on the second side.

Lap welds are more wasteful of plate material than butt welds. Still there are places where the lap weld, permitting as it does at times more ready field erection and fit-up, is preferred to the butt weld. Furthermore, the repair of existing oil storage tanks with lap welded patches follows the original design of most of these tanks.

Both plug and slot welds as used in connection with lap welds have their advantages. The plug weld is quite satisfactory in the hands of a capable welder. A great deal of attention should be given to the deposition of the first bead that joins the edges of the hole in the upper plate to the lower plate. Once this bead is made correctly, completion of the plug weld is exceedingly simple. Some operators like to burn several electrodes before cleaning off the accumulated slag. Where the welder is familiar with this procedure, valuable time may be saved without detracting a whit from the perfection of the weld.

Slot welds add the advantages of a longer weld with greater fusion area to a more common joint design with an elongated welding trough. Ease of cleaning has promoted this modified plug weld among welders. Here, as in the plug weld, the first bead along the periphery of the root of the groove is the most important part of the job. Again the melting of several electrodes (in metallic-arc welding) is recommended for trial where the welding personnel is able to cope with this procedure.

The corner joints welded from one side only are subject to the same weakness mentioned for the single-welded butt joint: the root will not withstand bending tension. Inside fillet welds do away with this objection of course. And the double-welded corner weld with a reinforcing fillet is a very fine construction. Likewise the thin-gauge edge weld offers no resistance to internal pressure acting against the bottom of the weld. The grooved-edge weld prescribed for heavier plate material has no strength at the base of the weld either, when bending tension is applied, and should not be so located.

The few basic designs of grooves reviewed in this article will serve the refiner well for all of his weldments. The regular fillets used in structural welding and the tees formed by the welding of an upright member to a horizontal member with fillets on both sides have not been discussed. Usually no problem of joint design is involved with this type of construction.

Attention has been focused on the reasons for designing some joints. Always the lessons learned in the school of experience have been applied to the problem of groove contour. It is surprising how much effort must be expended to overcome the slightest change in fundamental joint dimensions. In the same class is the need for good fit-up as the best design can be ruined by faulty workmanship in the fit-up gang.

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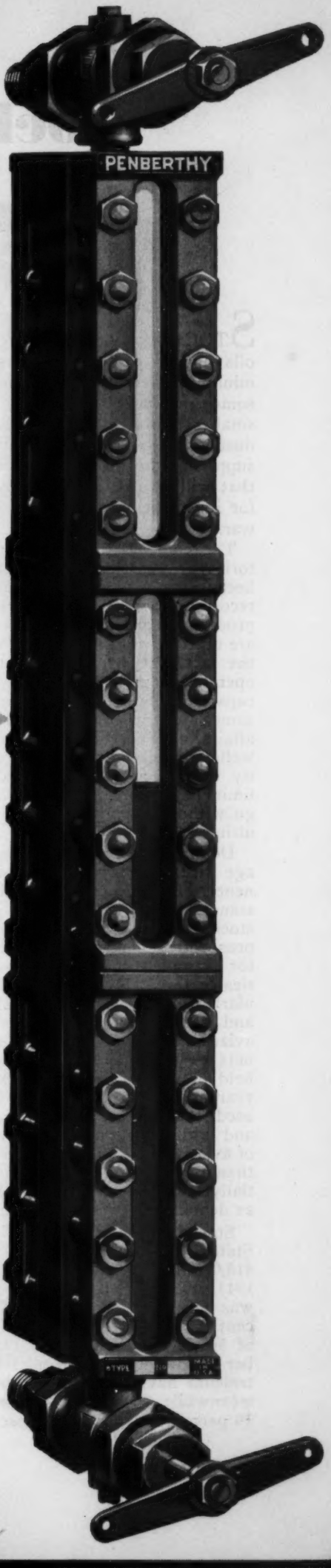


Stocks Reduced Under War Demand

L. J. LOGAN

STOCKS of crude and refined oils appear to be very close to minimum requirements, and in some instances, inventories are smaller than desirable, as the industry faces the responsibility of supplying the petroleum products that will be needed by the nation for its participation in a far-flung war.

The comparatively light inventories are particularly significant because they exist in the face of record-breaking production and processing of crude. The stocks are reacting only normally, despite the fact that refineries are being operated around 90 percent of rated capacity, while in the opinion of some students of the industry's affairs, all but comparatively few wells are being produced at capacity or else at rates close to the limits beyond which they could not go without damage or sacrifice of ultimate recovery.

Detailed examination of the storage situation brings into prominence, furthermore, several instances of exceptionally light stocks in relation to current and prospective demand. It is found, for example, that there are scarcities or threats of scarcities particularly of lubricants, heavy fuel oils, and natural gasoline, as well as aviation gasoline. All these products except aviation gasoline are held in smaller quantities than a year ago, whereas they are being used in materially larger volumes; and while there are more barrels of aviation gasoline in storage now than a year ago, there are substantially fewer days' supply on hand, as demand has greatly increased.

Stocks of all oils in the United States totaled approximately 553,415,000 barrels on December 31, 1941, it is indicated. That amount was only 10,500,000 barrels (2 percent) less than the reported total of 563,954,000 barrels for December 31, 1940. But demand for petroleum having increased sharply meanwhile, the present stocks are 10 percent smaller than those held a year ago, in terms of days' supply. The stocks of the end of 1941 represented only 128 days' supply, on the basis of daily average requirements during 1941, whereas the end-of-1940 stocks had been equivalent to 142 days' supply at the rate of demand during 1940.

Crude Stocks Down

The reduction of stocks of all oils has reflected particularly a material withdrawal of crude from storage, which occurred despite record-breaking production for the year. Refinable crude in storage in the United States on December 27, 1941, totaled 243,990,000 barrels, which was 20,000,000 barrels (7.6 percent) less than the 264,079,000 barrels in the tanks December 31, 1940.

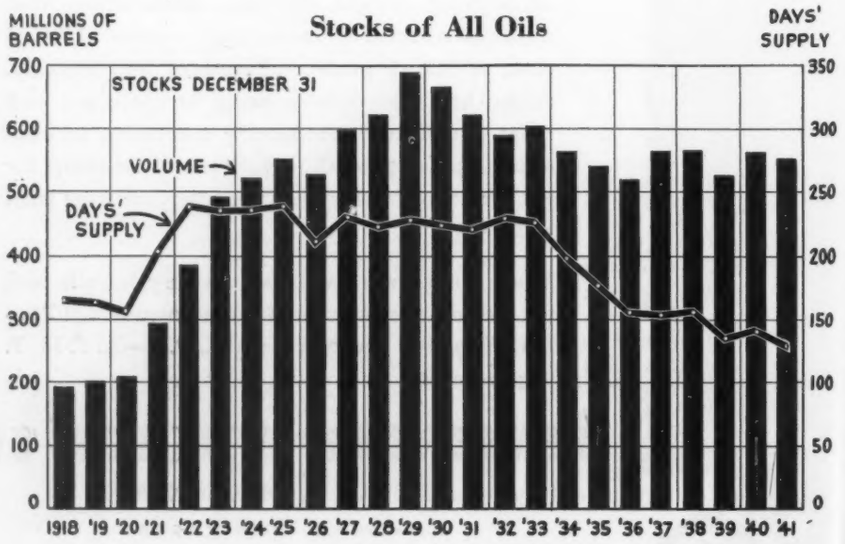
The decrease in crude stocks from a year ago has been considerably greater on the basis of days' supply than in actual barrels. On the basis of indicated daily average requirements for January, the stocks on hand at the close of 1941 represented only 57 days' supply, whereas those of the end of 1940 were equivalent to 72 days' supply. These figures indicate a decrease of 15 days' supply or 20.8 percent in available storage crude since a year ago.

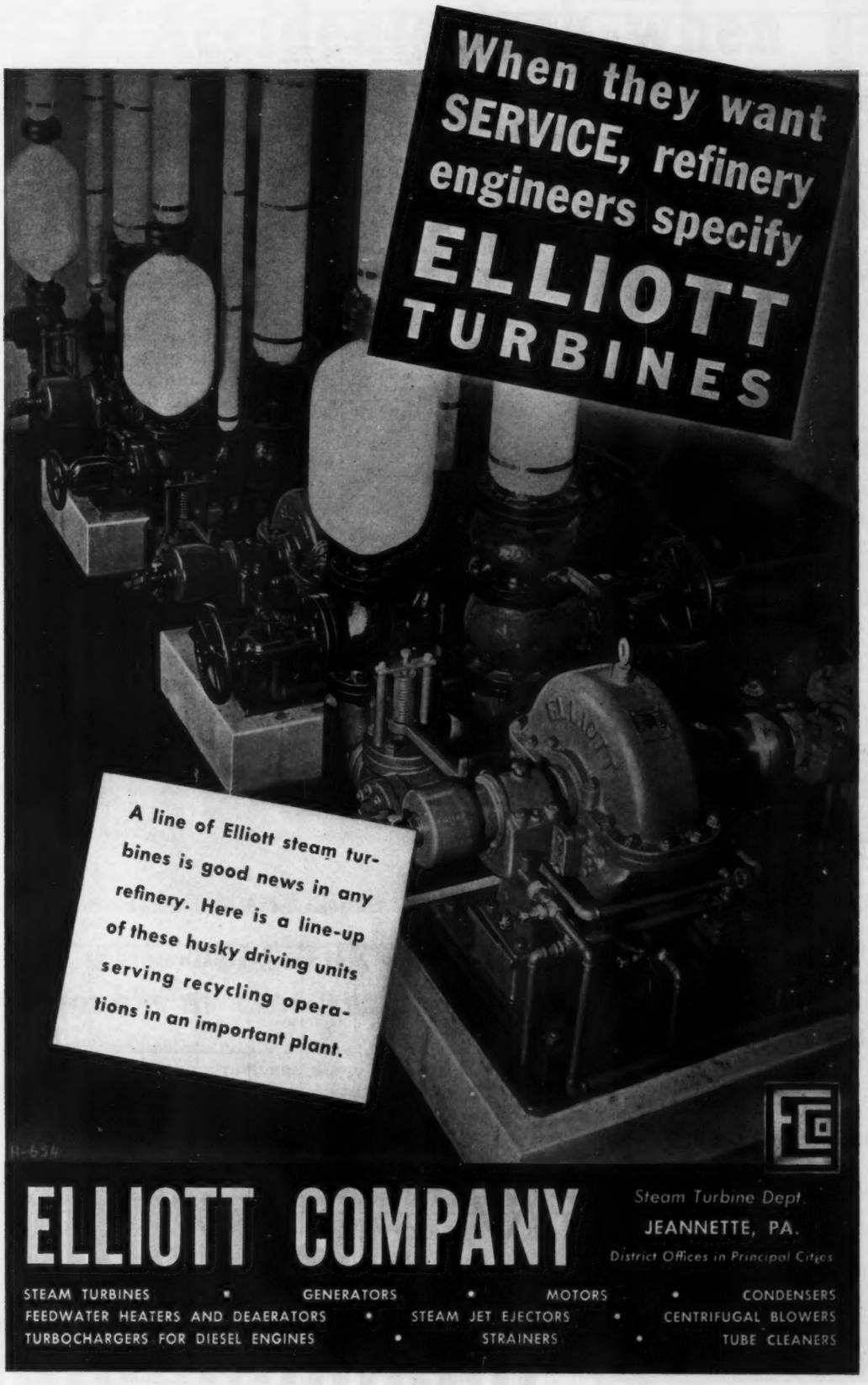
Heavy crude oil in California, not refinable and used as heavy fuel oil, likewise has been taken from storage, and stocks of 9,925,000 barrels on December 27, 1941, were approximately 2,000,000 barrels (16.6 percent) less than those of 11,906,000 barrels reported for December 31, 1940.

Natural gasoline stocks now are undesirably low, as refiners have been using all available supplies, from current production and from inventory, in blending with refined gasolines in their attempts to meet the heavy demands for aviation gasoline and high-octane automotive gasoline, the natural furnishing needed volatility and other qualities in manufacture of the premium motor fuels. Evidence of the scarcity of natural gasoline is furnished in tight markets and relatively high prices as well as in the statistics on stocks.

Refined Products

In actual volume, the stocks of all refined products are nearly 5 percent larger than a year ago, having totaled approximately 295,500,000 barrels on December 31,

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Stocks of Crude Oil and Refined Products

Estimates December 31, 1941 (Bureau of Mines and A.P.I.)

(Barrels)

ITEM	Dec. 31, 1940 (Bureau of Mines)	Dec. 31, 1941 (Estimated)	Change During Year	
			Barrels	Percent
All Oils:				
Amount on Hand	563,954,000	553,415,000	—10,539,000	— 1.9
Days' Supply on Basis of Daily Average Demand During Year	142	128	—14	— 9.8
SUMMARY OF PRINCIPAL ITEMS:				
Crude Petroleum:				
Amount of Refinable in United States	264,079,000	243,990,000*	—20,089,000	— 7.6
Days' Supply of Refinable in U. S., on Basis of Indicated Daily Average Demand in January, 1942	72	57	—15	— 20.8
Heavy in California	11,906,000	9,925,000*	—1,981,000	— 16.6
Natural Gasoline	5,704,000	4,000,000	—1,704,000	— 29.8
Refined Products:				
Total Amount, All Products	282,265,000	295,500,000	+ 13,235,000	+ 4.7
Days' Supply, on Basis of Daily Average Demand for all Oils During Year	71	68	—3	— 4.2
STOCKS OF FINISHED PRODUCTS, ITEMIZED:				
Gasoline:				
Finished	77,943,000	84,600,000	+ 6,657,000	+ 8.5
Unfinished	6,466,000	7,900,000	+ 1,434,000	+ 22.1
Total	84,409,000	92,500,000	+ 8,091,000	+ 9.6
Days' Supply of Motor Fuel (Finished Gasoline and Natural Gasoline), on Basis of Daily Average Demand During Year	50	47	—3	— 6.0
Aviation Gasoline (Included Above with Gasoline):				
Amount	6,285,000	7,500,000	+ 1,215,000	+ 19.3
Days' Supply, on Basis of Daily Average Demand During Year	202	160	—42	— 20.8
Gas Oil and Distillate Fuel:				
Amount	42,940,000	50,500,000	+ 7,560,000	+ 17.6
Days' Supply, on Basis of Daily Average Demand During Year	87	94	+7	+ 8.0
Residual Fuel Oil:				
Amount	89,304,000	86,000,000	— 3,304,000	— 3.7
Days' Supply, on Basis of Daily Average Demand During Year	92	77	—15	— 16.3
Kerosene:				
Amount	9,512,000	10,200,000	+ 688,000	+ 7.2
Days' Supply, on Basis of Daily Average Demand During Year	48	50	+2	+ 4.2
Lubricating Oil:				
Amount	8,767,000	7,800,000	— 967,000	— 11.0
Days' Supply, on Basis of Daily Average Demand During Year	91	68	—23	— 25.3
Other Refined Products	47,333,000	48,500,000	+ 1,167,000	+ 2.5

* Stocks reported by Bureau of Mines as of December 27, 1941

1941, compared with 282,265,000 barrels on December 31, 1940, an increase of 13,235,000 barrels.

In terms of days' supply at prevailing rates of demand, however, refined product stocks are smaller now than a year ago. The stocks on hand at the end of 1941 were equivalent to only 68 days' supply at the daily average rate of demand for all oils during 1941, whereas the inventory held at the close of 1940 was equivalent to 71 days' supply at the rate of demand that year. The past year brought, therefore, a decrease of aggregate refined oil stocks in the amount of 3 days' supply, or 4 percent, despite the 13,000,000-barrel increase in actual volume.

Gasoline Stocks

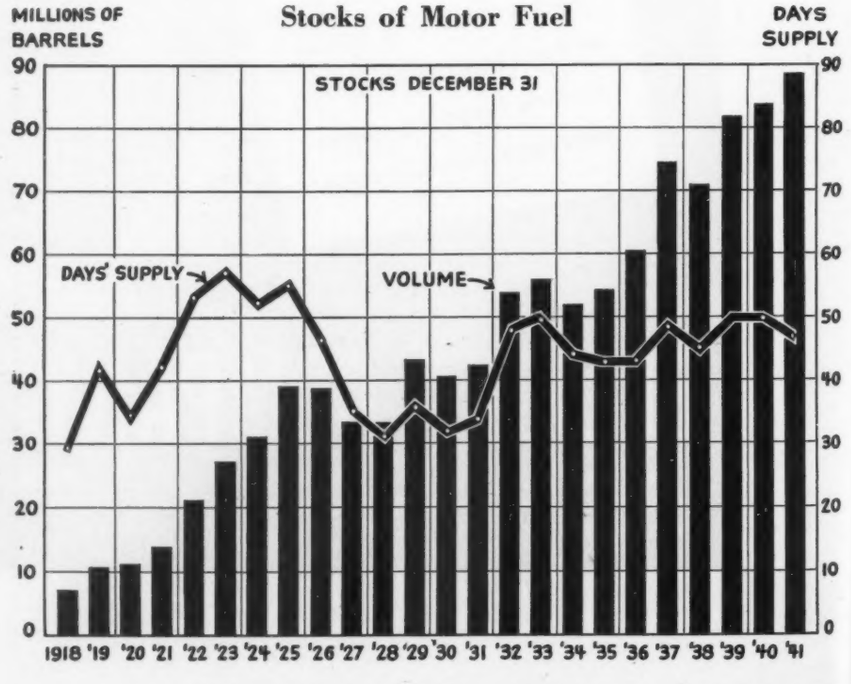
As in the case of refined products in the aggregate, gasoline is held in larger quantity than a year ago, but present storage represents fewer days' supply than did the stocks at the close of 1940.

Finished and unfinished gasoline in storage on December 31, 1941, totaled approximately 92,500,000 barrels, compared with 84,409,000 barrels on December 31, 1940, an increase of a little over 8,000,000 barrels or 9.6 percent.

Stocks of motor fuel, including finished gasoline and natural gasoline, were up to about 88,600,000 barrels on December 31, 1941, from 83,647,000 a year previously, an increase of 5,000,000 barrels or 6 percent in actual volume; but the new total represented only 47 days' supply, compared with 50, on the basis of the higher daily average demand for 1941, a decrease of 3 days' supply, or 6 percent.

Aviation Gasoline

In reflection of war time expansion of United States capacity to produce aviation gasoline, output has been stepped up sufficiently to satisfy current domestic and export demands and in addition to permit some increase in stocks, as regards actual volume, although present storage is relatively lighter than that of a year ago, considering the sharply higher current needs. Stocks on December 31, 1941, totaled about 7,500,000 barrels, it is indicated, compared with 6,285,000 barrels a year earlier, an increase of 1,215,000 barrels or 19.3 percent. However, demand being much greater, present stocks



Accidents lurk when power and speed crowd *PIPING TURNS* too!

In 6-day bicycle races, if riders come to grief—it's usually on the turns where speed and strain increase the danger. (I.N.S. photo)

Weld piping with TUBE-TURN fittings to prevent trouble at the crucial spots!

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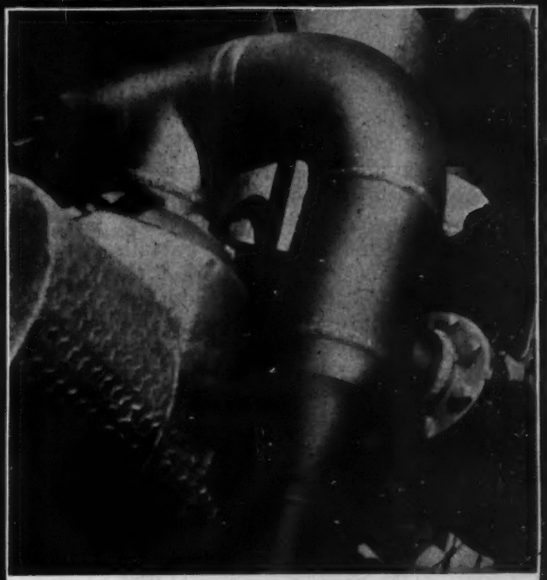
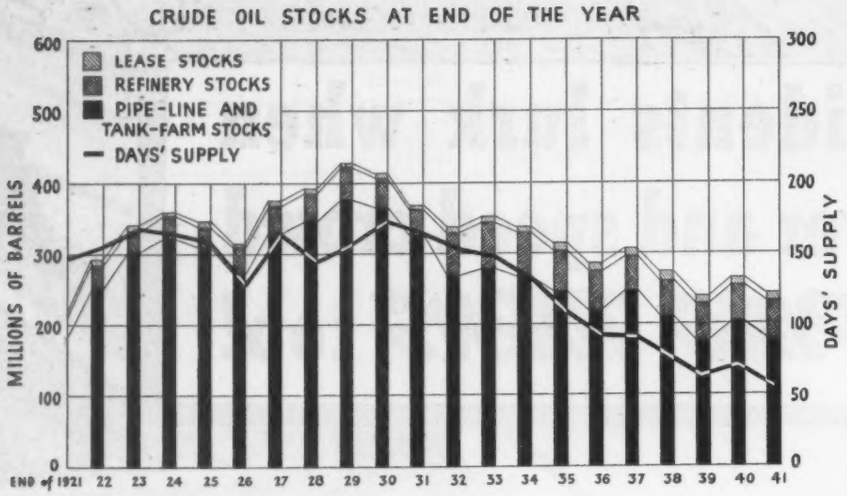
HOW TUBE-TURN FITTINGS PROTECT WHERE FLOW DIRECTIONS CHANGE



This compact piping installation illustrates four common points that occasion *changes in flow direction*—a welding tee at the top, then a 90° elbow, a reducing outlet welding tee at the right, and a concentric reducer near the bottom. Tube-Turn welding fittings are used here to guard against danger at these turns.



represent only 160 days' supply on the basis of daily average requirements in 1941, whereas those of a year ago were equivalent to 202 days' supply. During 1942, there is to be expected a continuance of a tightness of supplies of this product, despite plans to quadruple manufacturing capacity by the end of the year or mid-1943, as war requirements will continue to absorb all the material available, with aircraft production rapidly expanding.

Lubricant Stocks Down

Stocks of lubricating oil were reduced approximately a million barrels (11 percent) during the past year, having come down to about 7,800,000 barrels as of December 31, 1941, from 8,767,000 a year earlier. In terms of days' supply, the reduction was larger than in terms of barrels, as storage at the close of 1941 was equivalent to only 68 days' requirements at the daily average rate of demand during the year, whereas stocks a year earlier had represented 91 days' supply. The year brought, therefore, a reduction of stocks in the amount of 23 days' supply, or 25 percent.

Despite indicated curtailment of the use of automobiles, there will be continued large domestic consumption of lubricants in the United States, with industrial use larger; and substantially increased exports are in prospect, for supplying war needs of the country's allies. Consequently, some difficulty may be experienced in maintaining adequate stocks.

Heavy Fuel Oils

The nation will need large quantities of heavy fuel oil during the war, for naval and merchant-marine operations, for heavy railroad traffic, for mines, smelters, and factories, for production of electricity, and for fuel uses of the oil industry. Consequently, the present relative scarcity of residual fuel oil will continue and perhaps be accentuated, especially inasmuch as refiners have no inducement price-wise for turning out any more of this residue product than necessary.

Stocks on hand December 31, 1941, totaled about 86,000,000 barrels, having been 3,304,000 barrels (3.7 percent) lower than a year earlier, and the inventory represented only 77 days' supply at the daily average rate of demand during 1941, whereas stocks at the end of 1940 were equivalent to 92 days' supply, indicating a decrease within the past year of 15 days' supply, or 16.3 percent.

The reduction in stocks of residual fuel oil during the past year was accounted for almost wholly by California. That state had only 53,072,000 barrels in storage on October 31, 1941, the Bureau of Mines reported, against 59,892,000 on December 31, 1940. Outside California, stocks currently are larger than a year ago, in actual volume.

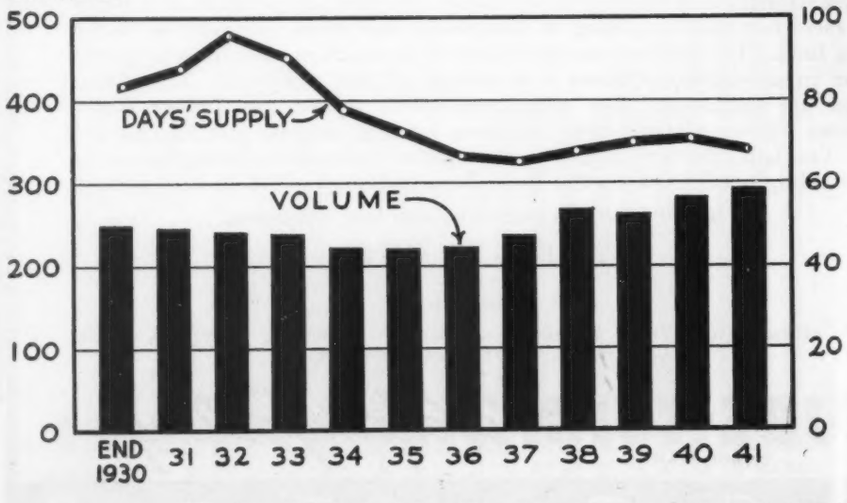
Heating Oil and Kerosine

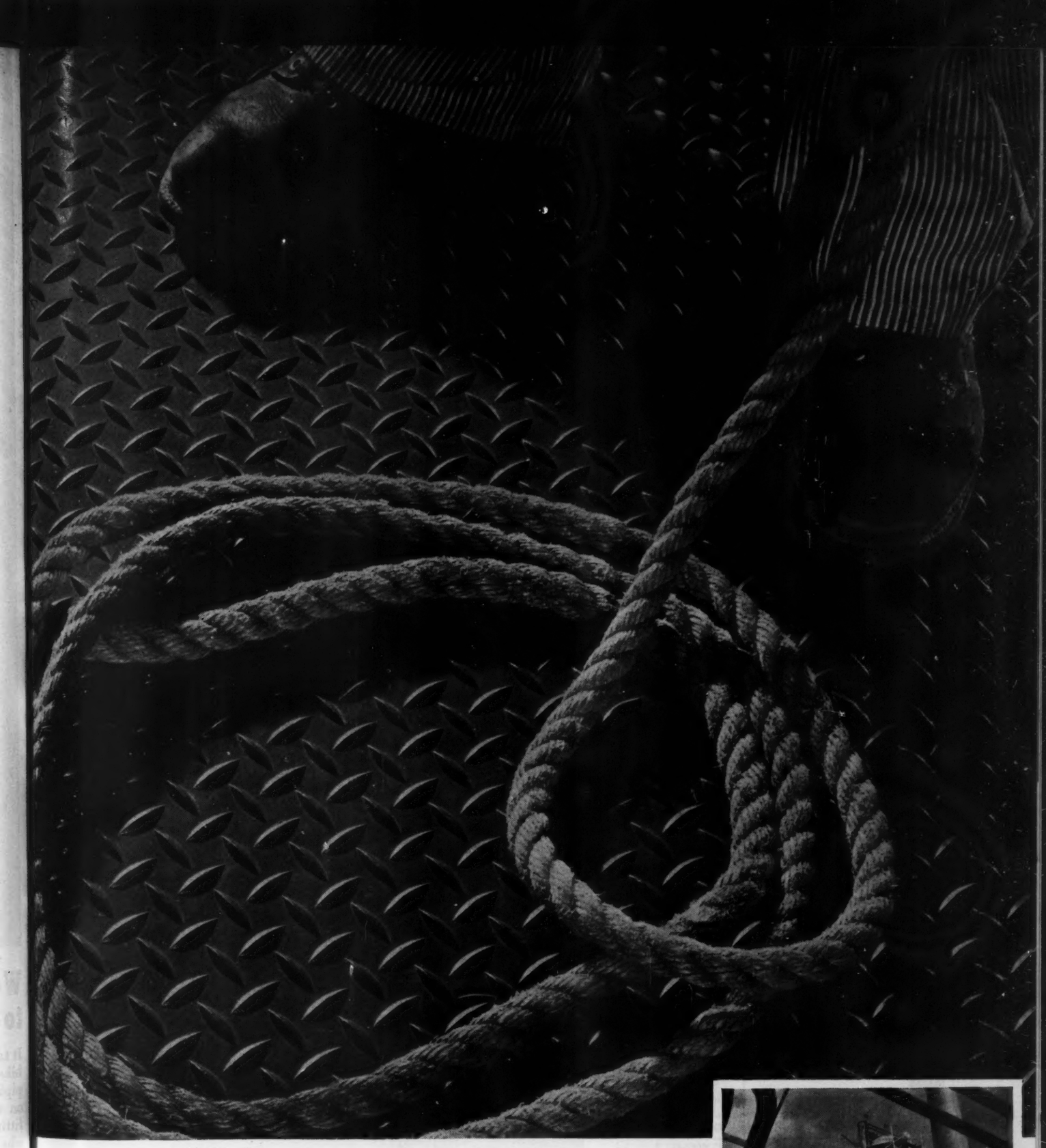
Stocks of light fuel oil and kerosine are relatively more ample now than those of other major products, as less severe weather than normally has held down consumption this winter, following special efforts of the industry to build up a large inventory to take care of possible heavy requirements.

Gas oil and distillate fuel, consisting in large part of heating oil, was held in storage in the amount of about 50,500,000 barrels on December 31, 1941. That was 7,560,000 barrels more than the 42,940,000 reported for the end of December a year previously, an increase of 17.6 percent in the volume on hand. However, the year-to-year increase in stocks was only 8 percent in terms of days' supply, the inventory of the close of 1941 having been equivalent to 94 days' requirements on the basis of daily average demand during the year, whereas that of the end of 1940 represented 87 days' needs.

Stocks of kerosine in the United States on December 31, 1941, amounted to about 10,200,000 barrels and were 688,000 barrels (7.2 percent) above those of 9,512,000 barrels held a year before. The new total was equivalent to 50 days' supply at the daily average rate of demand in 1941, whereas the stocks of a year previously had represented 48 days' supply.

Year-End Stocks of Refined Products





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Liquefied Petroleum Gas in 1941

G. G. OBERFELL, Vice President
Phillips Petroleum Company

THE year 1941 was a most unusual one for the liquefied petroleum gas industry—a year which made new highs in marketed production for all types of uses in spite of the difficulty in obtaining materials for new installations, curtailment of sales activities in many quarters because of inability to secure customer equipment and appliances, and restrictions on appliance financing. It was a year which saw a great increase in the industrial uses of liquefied gases in defense work and an increase in the amounts of certain associated hydrocarbons used in the manufacture of synthetic rubber and plastics.

Table 1 shows the estimated marketed production of liquefied petroleum gas during 1941 as 445,000,000 gallons, compared with 313,456,000 gallons for 1940, or an increase of 42 percent.

Table 1 "total sales" for all years except 1941 were obtained from United States Bureau of Mines report. "Distribution" for the years 1931 to 1940 inclusive was obtained from the same source. All other volumes are estimated by the writer. Total sales volumes include all liquefied petroleum gas (propane, butane, butane-propane mixtures, and pentane) when sold as such. It includes sale of pentane when sold for any purpose other than motor-fuel blending. It does not include butane when blended with heavier petroleum fractions for motor-fuel purposes nor does it include sales of hydrocarbon gases delivered by pipe line in the gaseous state to certain large chemical concerns located adjacent to the points of production of the hydrocarbon gases; however, such sales for chemical maufacturing purposes are included if the liquefied petroleum gases are transported by tank car or tank truck in liquid form. Purchases of liquefied petroleum gases by one company from another and then resold as liquefied petroleum gas have been eliminated in order to avoid duplication of sales figures. Table 1 does not reflect those quantities of liquefied petroleum gas used by producers for such purposes as fuel, solvents, dewaxing, and for gasoline manufacturing purposes.

The estimated domestic use of liquefied petroleum gas in 1941 amounts to 221,880,000 gallons, an increase of 65.5 percent over 1940 when 134,018,000 gallons (42.7 percent) were so consumed. On the basis of the most reliable information available to the writer, the number of new domestic users of liquefied petroleum gas increased approximately 520,000 during the year. It is now estimated that there are a total of 1,645,000 users of liquefied petroleum gas in the domestic and small commercial classification—a growth due largely to increasing public acceptance of liquefied petroleum gas as an ideal domestic and commercial fuel. It appears that the largest increase in new domestic customers was secured by marketers employing aboveground equipment (propane in stationary or replaceable cylinders), with the underground equipment marketers (butane or butane-propane mixtures in buried containers) also scoring a substantial increase. There was some increased use of "liquid feed" systems (butane-propane mixtures which are fed to a special vaporizer near the point of consumption). Doubtless many additional thousands of domestic and commercial consumers

TABLE 1

Marketed Production of Liquefied Petroleum Gas

YEAR	TOTAL SALES		DISTRIBUTION—GALLONS PER YEAR					
			Domestic		Industrial and Miscellaneous		Gas Manufacturing	
	Gallons	Percent Increase Over Previous Year	Gallons	Percent Increase Over Previous Year	Gallons	Percent Increase Over Previous Year	Gallons	Percent Increase Over Previous Year
1922	222,641	....	.....	....	.....	....	.....	....
1923	276,863	24.4*	.....	....	.....	....	.....	....
1924	376,488	36.0*	.....	....	.....	....	.....	....
1925	403,674	7.2*	.....	....	.....	....	.....	....
1926	465,085	15.2*	.....	....	.....	....	.....	....
1927	1,091,005	134.6*	.....	....	.....	....	.....	....
1928	4,522,899	314.6	2,600,000	....	400,000	....	1,500,000	....
1929	9,930,964	119.6	5,900,000	126.9	1,500,000	275.0	2,500,000	66.7
1930	18,017,347	81.4	11,800,000	100.0	2,200,000	46.7	4,000,000	60.0
1931	28,769,576	59.7	15,294,648	29.6	7,171,686	226.0	6,303,242	57.6
1932	34,114,767	18.6	16,244,103	6.2	8,167,194	13.9	9,703,470	53.9
1933	39,931,008	14.1	16,625,588	2.3	13,987,095	71.3	8,318,325	14.3
1934	56,427,000	44.9	17,681,000	6.3	32,448,000	132.0	6,298,000	24.3
1935	76,855,000	36.2	21,380,000	20.9	47,894,000	47.6	7,581,000	20.4
1936	106,652,000	38.8	30,014,000	40.4	67,267,000	40.5	9,371,000	23.6
1937	141,400,000	32.7	40,823,000	36.0	89,402,000	32.9	11,175,000	19.3
1938	165,201,000	16.7	57,832,000	41.7	94,983,000	6.2	12,386,000	9.8
1939	223,580,000	35.3	87,530,000	51.3	120,615,000	27.0	15,435,000	24.6
1940	313,456,000	40.2	134,018,000	53.1	159,153,000	32.0	20,285,000	31.4
1941	445,000,000	42.0	221,880,000	65.5	193,456,000	21.4	29,644,000	46.1

* Sale of liquefied petroleum gas confined primarily to bottled gas business prior to 1928.

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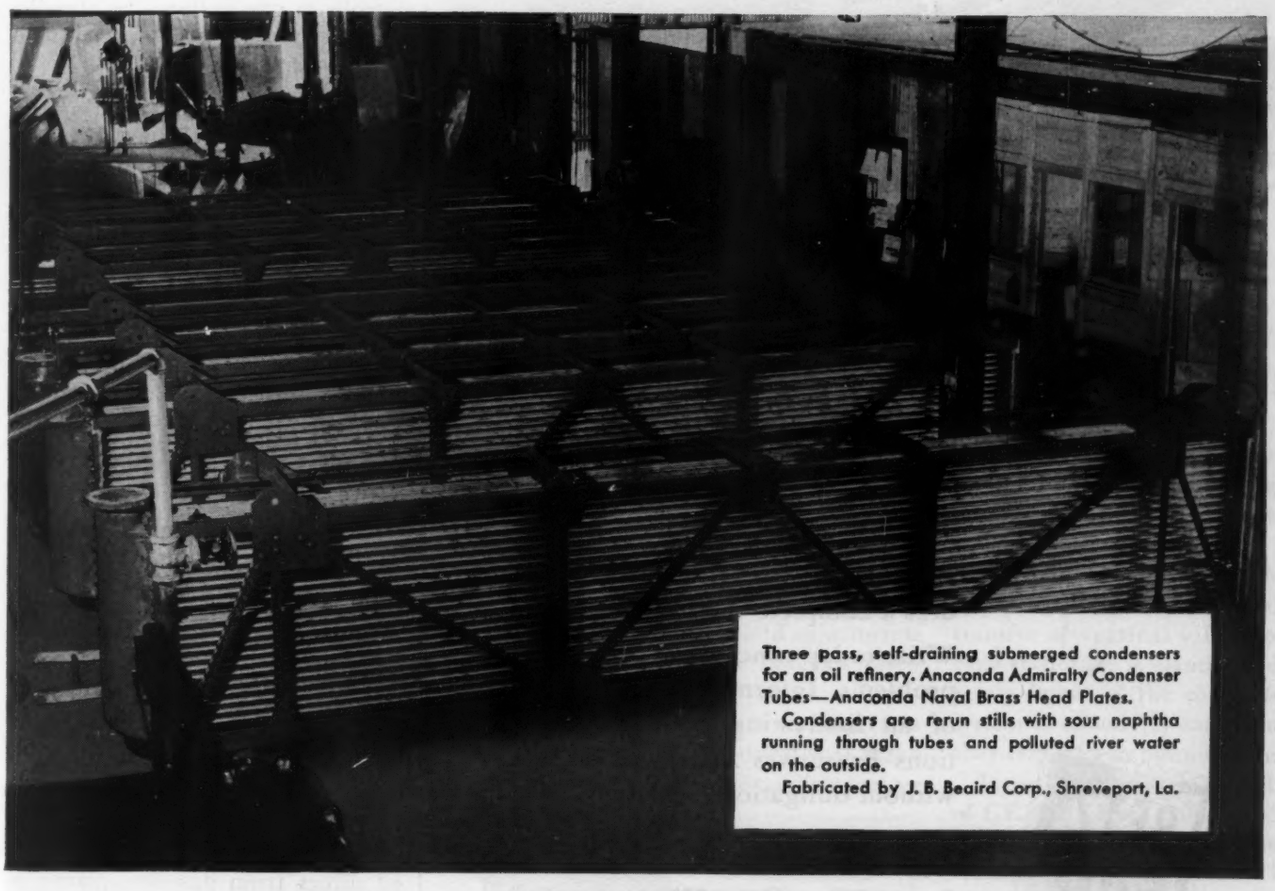
A NEW PLANT, plus expanded facilities elsewhere, is our answer to the heavy demand for condenser tubes from war-vital industries.

Anaconda offers a wide range of alloys for condenser and heat exchanger tubes, and is producing these tubes in increasing quantities by all commercial methods.

We have a valuable 58-page book on Anaconda Tubes and Plates. If you haven't a copy, just ask for Publication B-2, 5th Edition.

And don't forget, if you are in need of technical advice, that our engineers have had many years of experience in the study and solution of condenser tube problems. 4281A



Three pass, self-draining submerged condensers for an oil refinery. Anaconda Admiralty Condenser Tubes—Anaconda Naval Brass Head Plates.

Condensers are rerun stills with sour naphtha running through tubes and polluted river water on the outside.

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REPRESENTED IN ALL INDUSTRIAL AREAS IN U. S. A. AND CANADA

could have been secured in 1941, had it been possible for the marketers, their distributors and dealers to secure the necessary appliances and equipment with which to make additional installations.

Industrial Installations

Many new industrial installations were made, principally in the heavy manufacturing areas in the North and East, and a majority use propane, delivered in tank car quantities. There was little difficulty in installing these systems since nearly all of the plants were in defense work, and carried high priorities for equipment. From these installations, liquefied petroleum gas is used in the manufacture of battleships, machine guns, tanks, hydraulic pumps, aluminum shapes, shells, airplane parts, cruisers, destroyers, tankers and ordnance of all types. Due to heavy demands being placed on regular utilities, many large industrial concerns have installed liquefied petroleum gas systems as standby to insure gas service for vital manufacturing operations during periods when the utility system has high peak loads. As existing industrial plants throughout the country became more heavily engaged in defense work, an increasing percentage of liquefied gas sold to industrial and utility plants is going into the making of defense articles.

Liquefied petroleum gas systems have been installed to furnish piped gas service for several large housing projects in defense areas. The gas is delivered to some of the plants via tank car and to others via tank truck. One very large utility installation is being completed in an Ontario city, where normal requirements are met with natural gas. The liquefied petroleum gas is to be used to supplement oil-gas for standby and peak load control. Over 200 cities are now employing or arranging to use undiluted butane or propane, propane-air, butane-air, propane, butane, or mixtures for the sole source of gas or for standby, peak load control, or enrichment.

Increasing quantities of liquefied petroleum gas were transported direct from gasoline plants or refineries to consumers, or from pipe line terminals to consumers in 1941.

Chemical Uses

In the chemical field, liquefied petroleum gases became an in-

creasingly important source of raw material. Volume shipments of special grades of propane, normal butane, isobutane, and butadiene were made for use in the manufacture of nitro-paraffins, plastics, and synthetic rubber. For experimental and pilot-plant operations such special hydrocarbons as propylene, butylene, isobutylene, and others are now available in pure and technical grades.

Competition for the domestic markets continues keen from both within and without the industry, electricity being the principal competitor from without the industry for this large potential domestic consumer market. Prices within the industry have, in general, strengthened, particularly in the Southwest.

In addition to increasing volumes absorbed in present markets during 1941, new uses began to require appreciable volumes of hydrocarbons in the liquefied gas range. Among these were butadiene and isoheptene for manufacturing synthetic rubber, diolefins for plastics, propane for nitro-paraffins, and normal butane for conversion into isobutane in the manufacture of aviation gasoline by the isomerization and alkylation processes.

Nineteen forty-one saw the first large scale installation of propane-fired heaters for removing accumulations of ice and snow on switches in railroad yards. The installation was made after limited trial operations during the winters of 1939-40 and 1940-41.

Additional special high-pressure tank cars and transport trucks were required to deliver the increased volumes in 1941. It is estimated that orders for more than 200 new tank cars were placed with car builders in 1941. All tank cars ordered have not been delivered due to defense demands for heavy steel plates, which fact accounts for some increased transportation by tank trucks, especially in the areas where relatively short hauls are involved. Arrangements have been made by one marketer to transport large volumes of butane from Texas to many industrial users in a large midwestern city (a distance of about 1100 miles) by a combination of pipe line and by transport truck. These heavy-duty transport trucks were fabricated in accordance with the standards and regulations of the National Board of Fire Underwriters and of the Bu-

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Before shipment to you, every GENSPRING Constant-Support Hanger for power piping is *individually* tested at the factory under load-and-travel conditions that duplicate the actual service specifications. However, should you find it necessary, field adjustments up to ± 16% of the hanger's rated load are easily made.

These are only two of the manufacturing and design features that make GENSPRING the outstanding hanger for today's high-temperature power service. Through unique engineering design GENSPRING Hangers provide constant support for piping in every "hot" and "cold" position. The weight of pipe is always in perfect balance . . . transfer of vertical vibration to the pipe structure is eliminated . . . the safety factor of the complete piping system is effectively maintained. Yet they require a minimum of headroom.

Investigate the exclusive advantages of GENSPRING Constant-Support Hangers available to support loads from 250 to 8500 pounds. Their cost is kept to a minimum through interchangeable parts and mass production. Grinnell Company, Inc., Executive Offices, Providence, R. I. Branch offices in principal cities of U. S. and Canada.

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reau of Motor Carriers of the Interstate Commerce Commission.

Certain marketers, realizing the importance of safety in the design, installation, and operation of liquefied petroleum gas equipment, have placed increased emphasis on this phase of the business. Safety meetings for operating personnel were made a regular procedure in some instances. Safety meetings also were held by marketers for their dealers. Many companies secured new listings of their systems with Underwriters' Laboratories, and other regulatory authorities. The industry is to be complimented on its increased emphasis on safety although further work is required.

Many states have enacted laws requiring payment of motor fuel taxes on only those quantities of liquefied petroleum gas sold or used to propel motor vehicles upon the public highway. These states, together with the effective date of such legislation, are as follows:

Washington, July 1, 1941; California, July 1, 1937; Nevada, July 1, 1939; Utah, May 13, 1941; Arizona, July 1, 1941; New Mexico, July 1, 1939; North Dakota, July 1, 1941; South Dakota July 1, 1941; Nebraska, September 8, 1939; Kansas, July 1, 1941; Oklahoma, April 12, 1939; New Jersey, July 12, 1939; Texas, May 1, 1941; Missouri, October 10, 1941; Maine, July 26, 1941; Arkansas, July 1, 1941; Louisiana, July 31, 1940; Wisconsin, October 6, 1939; Illinois, July 19, 1939; Kentucky, May 13, 1936; Tennessee, February 15, 1941; Mississippi, May 1, 1938; Alabama, August 1, 1940; Florida, July 1, 1939; North Carolina, July 1, 1941; Iowa, July 4, 1941; Minnesota, April 28, 1941.

In 1941 additional states have adopted rules and regulations governing the safe storage, handling, transportation, and utilization of liquefied petroleum gas. A large percentage of these regulations were in substantial conformity with the National Board of Fire Underwriters' standards. These states now have liquefied petroleum gas rules and regulations:

New Mexico, Oklahoma, California, Kansas, Arkansas, Indiana, Michigan, South Dakota, Minnesota, Louisiana, Texas, Alabama, Kentucky, Tennessee, Iowa, Mississippi, and Wisconsin.

Close cooperation between the industry and the various national, state and local regulatory and insurance bureaus and associations has resulted in the desirable and widespread establishment of uniform rules and regulations.

Equipment Shortage

As the year 1941 ended, the liquefied petroleum gas industry found itself in a most difficult position from the standpoint of obtaining equipment with which to make new customer installations in 1942. During the latter part of 1941, several marketers of domestic systems had placed their dealers on an allocation basis, allowing them only a certain percentage of 1940 system and appliance sales. Copper, aluminum, zinc, synthetic rubber, steel and other materials have been widely used in liquefied petroleum gas systems and appliances, and, of course, all are critical materials. With war underway, the industry's new sales probably will come close to a halt as soon as the available warehouse stocks are used up. Equipment companies catering largely to the liquefied petroleum gas industry already have or are rapidly switching over a portion of plant facilities from the manufacture of liquefied petroleum gas industry articles to war items.

Substitute Materials

However, certain leading marketers and equipment manufacturers have spent considerable time on research work connected with development and use of substitute or alternate materials and equipment with noteworthy success. These efforts are being continued.

In view of restricted output and difficulty in obtaining necessary materials under war conditions, appliance manufacturers are working to eliminate or reduce the use of aluminum, chromium, and other critical materials and will undoubtedly reduce the number of models manufactured in 1942.

It appears that approximately as many new appliances will be obtainable as the number of new systems, including cylinders, which can be spared from war needs.

Federal regulations effective September 1, 1941, governing credit terms, have naturally affected the financing of appliances to the liquefied petroleum gas industry and its customers to some degree. These rules, established a minimum down payment of $5.00 per appliance sold, and limited the financing period to not more than 18 months on stoves and gas-fired refrigerators, and the financed amount to 80 percent of the sales price. Maximum terms on water heaters was 18 months and 85 percent of the sales price. These restrictions have not been detrimental, and all appliances available in 1941 were sold regardless of these restrictions.

Production facilities continue to expand at both refineries and natural gasoline plants, with the major output of the latter flowing into motor or aviaton fuel channels as raw material for blending, polymerization, alkylation and isomerization.

The following states now have liquefied petroleum gas production:

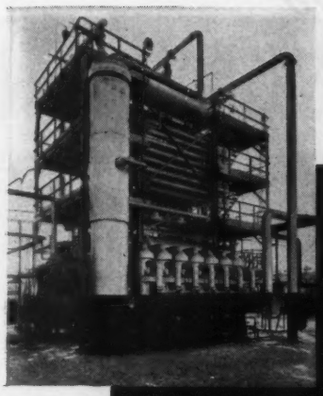
Massachusetts, New Jersey, Pennsylvania, West Virginia, Colorado, Kentucky, Indiana, Illinois, Arkansas, Texas, New Mexico, California, Ohio, Wyoming, Montana, Kansas, Oklahoma, and Louisiana; and Quebec, Canada.

Aviation Gasoline

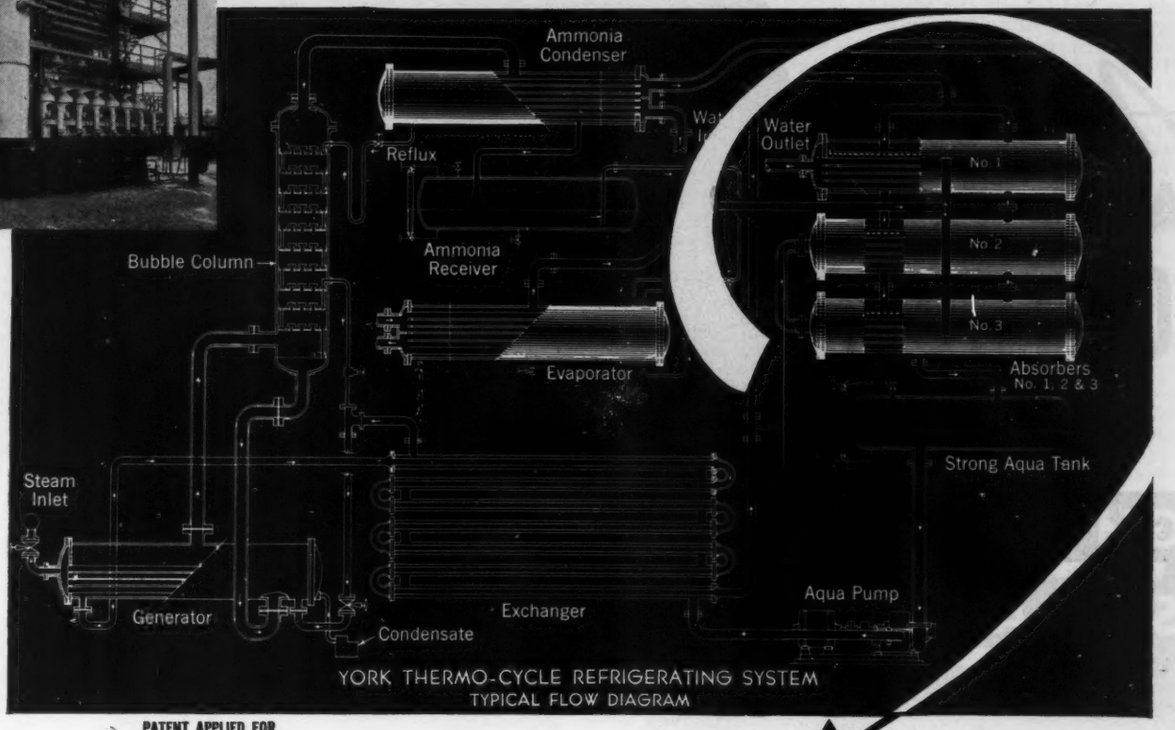
One trend in refining technology relating to the manufacture of aviation gasoline which will have a pronounced effect on the available supply of butanes to the liquefied petroleum gas industry is the process of isomerization of normal butane into isobutane, with the isobutane then being converted into aviation gasoline by either the thermal or catalytic alkylation processes. The demands for tremendous quantities of aviation gasoline under the war program has greatly stimulated the installation of new large-capacity isomerization and alkylation plants, and plans for further expansion along these lines throughout the petroleum industry are well under way.

It is still too early to estimate the volume of normal and isobutane to be required for the manufacture of aviation gasoline, however, it is reasonable to assume that large quantities heretofore available to the liquefied petroleum gas industry will soon go into aviation gasoline channels. Consequently, those marketers who have had a policy of marketing propane or furnishing storage and utilization equipment suitable for the use of propane are in a preferred position, and their customers will be better able to obtain liquefied petroleum gas in years to come.

This growing, young industry can well be proud of its 1941 record, during which it enabled many thousands of American families and hundreds of commercial establishments to have the convenience of gas service for cooking, water heating and refrigeration. Liquefied petroleum gas has also greatly aided in the manufacture of both civilian and vital defense articles, and will play an increasingly important role as the war production program progresses.



Here's help in boosting production of high Octane Gas



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2. Unusually flexible, it may be operated efficiently on any percentage of load.
3. Operation is automatic regardless of size of unit (up to 1,000 tons or more).
4. Designed for outdoor installation, the York System requires no buildings.
5. Fewer joints and parts (ammonia pump only moving part), the York System simplifies maintenance, reduces overhead.

Feature Number Two, of the new, super-efficient York Thermo-Cycle Refrigerating System is the Cascade Absorber. In these absorber units, special designing eliminates resistance to vapor and aqua flow thus permitting *maximum aqua concentration* for any given operating pressure and temperature. The result is reduced heat input and lowered water consumption per ton of refrigeration.

Special automatic controls feed the required amount of weak aqua to the absorbers as called for by the load, thereby controlling absorber pressure and maintaining maximum efficiency.

York Ice Machinery Corporation, York, Pennsylvania.

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A New AID TO CONTROL IN HIGH OCTANE DISTILLATION UNITS

"CONTINUOUS BALANCE" UNIT

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"AIR-O-LINE CONTROL" UNIT

OPM has requested the Oil Industry to step-up production of High-Octane Gasoline from 40,000 bbls. to 150,000 bbls. per day. Every refinery is mobilizing its resources on a wartime basis, and in a very real sense, production output depends on proper instrumentation.

In the control of Narrow Boiling Range Columns and other temperature applications, Brown brings to the Oil Industry a *new operating principle* in temperature measurement and control—*"Continuous Balance System"*—an advanced embodiment of electronics.

Change Made in WPRA Annual Convention

Instead of the three-day meeting of the Western Petroleum Refiners Association in New Orleans, March 23, 24 and 25, there will be a business session of one day. Date and place of this meeting will be announced later. Notice of the change was to the effect that some central point such as St. Louis, Kansas City or Tulsa would be selected. The announcement further read:

"Decision regarding the annual meeting was reached by the board of directors of the association only after careful consideration, and is felt to be in keeping with sacrifices that organizations, as well as individuals, should make in these days of wartime stress.

"Efforts are being exerted by officials of the association to have an outstanding government official from Washington discuss with the refiners the importance of their industry in the nation's wartime economy. No other speakers or papers are contemplated. It will be a strictly business session."

API Mid-Year Meeting To Oklahoma City

The twelfth mid-year meeting of the American Petroleum Institute will be held in Oklahoma City, May 25 through May 28. Headquarters will be in the Oklahoma Biltmore hotel.

The first two days will be devoted to committee meetings. Group sessions of both the Divisions of Production and Refining will be held morning and afternoon of May 27 and May 28. The board of directors will hold its session the morning of May 27. There will be a general session luncheon May 27.

New President of Shell Chemical Company

J. Oostermeyer has been elected president of Shell Chemical Company, following the resignation of C. B. de Bruign, who retired after 33 years with the organization.

Oostermeyer has been with the Shell organization for a quarter of a century. Since 1939 he has been vice president of Shell Chemical Company and for the last two years he has been actively concerned with the expansion of chemical plant facilities for the manufacture of chemical products from petroleum. The company is operating three such plants on the Pacific Coast, one at Dominguez, near Los Angeles, at Pittsburg and Martinez on San Francisco bay.

Officials Elected for McColl-Frontenac Company

John M. Pritchard has been elected president of McColl-Frontenac Oil Company, Limited, Montreal, Canada, succeeding J. A. Wales. C. P. Tomlinson was elected executive vice president. Both are former vice presidents, members of the executive committee and directors. Thomas C. Twyman, formerly assistant manager of the central territory of the sales department of The Texas Company, was elected a director and vice president in charge of marketing. G. R. Taylor, former manager of refining operations, was appointed vice president in charge of refining.

THE LOOK BOX

Douglas P. Bailey Is Director of District 2

Douglas P. Bailey has been appointed director of District 2 of the Office of the Petroleum Coordinator and will have headquarters in Chicago. The district includes Ohio, Kentucky, Tennessee, Michigan, Indiana, Illinois, Wisconsin, Minnesota, Iowa, Missouri, Oklahoma, Kansas, Nebraska, South Dakota, and North Dakota.

Bailey has been in the refining industry since 1922 when he joined Standard Oil Company (Indiana). Five years later he joined The Texas Company to which he returned in 1940 after six years as superintendent of a refining plant in France.

Additions to Staff Of Foster D. Snell

Recent additions to the staff of Foster D. Snell, Inc., consulting chemists, 305 Washington street, Brooklyn, include: Pat Macaluso, College of the City of New York; Edgar W. Goth, Grinzing College, Vienna; Peter Al Pfeiffer, Wesleyan University; Herbert H. Watjen, Brooklyn College.

Third Printing of Technical Manual

Members of the Natural Gasoline Supply Men's Association are being queried on the advisability of a third printing of the Technical Manual since the 4000 copies of two earlier printings have been distributed.

CONVENTIONS

MAR. 2– 5	American Society for Testing Materials, Spring Meeting, Cleveland.
APRIL 13–17	American Institute of Mining and Metallurgical Engineers, Cincinnati.
16–17	National Petroleum Association, Semi-Annual Meeting, Cleveland.
21–23	Southwestern Gas Measurement Short Course, University of Oklahoma, Norman.
22–24	Petroleum Industry Electrical Association, Washington-Youree Hotel, Shreveport.
MAY 11–13	American Institute of Chemical Engineers, Boston.
13–15	Natural Gasoline Association of America, Mayo Hotel, Tulsa.
25–28	American Petroleum Institute, Mid-Year Meeting, Oklahoma City.
JUNE 8–11	American Society of Mechanical Engineers, Semi-Annual Meeting, Cleveland.

Natural Gasoline Division Formed

Organization of the natural-gasoline division of the petroleum industry for its part in the making of 100-octane-aviation gasoline was started January 14, with a recommendation to the industry by Harold L. Ickes, Petroleum Coordinator for National Defense. District committees were named and duties outlined as follows:

"The natural gas and natural gasoline committees for the several districts shall obtain, compile and analyze all pertinent and available facts, figures and data with respect to the extraction, production, sale or disposition of butane, isobutane and isopentane by natural-gasoline-extraction plants, cycling plants, pressure-maintenance plants and repressuring plants. Such survey should include, without limitation, information concerning the number, type and location of such plants, the present daily capacities of such plants and the possibilities of expansion thereof, the percentage and amount of butane, isobutane and isopentane extracted from the gas processed at such plants, the percentage and amount of butane, isobutane and isopentane saved and sold during the calendar year 1941 at or by such plants.

"Within 30 days from the date hereof each owner or operator of a natural-gasoline-extraction plant, cycling plant, pressure-maintenance plant, or repressuring plant shall file in the Office of Petroleum Coordinator for National Defense a statement of the terms of existing contracts and agreements relating to the sale or other disposition of butane, isobutane, or isopentane either as free products or as they may be included in any other product.

"All persons, natural or artificial, presently owning or operating any natural-gasoline-extraction plant, cycling plant, pressure maintenance plant, or repressuring plant shall increase the percentage of butane and isobutane extracted from the gas processed at such plant, or plants, to the maximum quantity economically possible and shall increase the production of butane and isobutane in liquid form at such plant, or plants, to the maximum quantity economically possible.

"All new natural-gasoline-extraction plants, cycling plants, pressure-maintenance plants or repressuring plants shall be designed and constructed so as to make the most efficient use of scarce materials, to provide for the extraction of the maximum amount of butane and isobutane contained in the gas to be processed at such plants, and to assure the maximum production of butane and isobutane in liquid form at such plants."

James E. Pew of Charleston, West Virginia, has been named assistant to Paul M. Raigorodsky, chief of the natural gas and natural gas section of the office of the coordinator. He has been superintendent of the Virginian Gasoline & Oil Company.

Frank M. Brewster, Bradford, Pennsylvania, has been named chief of District 1 with Virgil F. Bowyer, Pittsburgh, as assistant chief. Brewster is on leave of absence as president of Belmont Quadrangle Drilling Corporation. Bowyer has been with Peoples Natural Gas Company. Within the district are 19 states and the District of Columbia. The committee will coordinate activities in this area but particu-

larly in the Pittsburgh-Cleveland-Youngstown industrial area, which annually consumes about 40 percent of the nation's natural gas.

D. E. Buchanan, president of Hanlon-Buchanan, Inc., Tulsa, has been named chief of District 3, with headquarters at Houston. This area embraces a large part of the natural gasoline production of the country as well as 90 percent of its cycling plants.

Personnel of the natural-gas and natural-gasoline committees for the five districts follow:

District No. 1: J. French Robinson, East Ohio Gas Company, Cleveland, chairman; Loring L. Tonkin, Hope Natural Gas Company, Clarksburg, W. Va.; G. E. Walker, United Natural Gas Company, Oil City, Pa.; H. A. Wallace, Jr., United Fuel Gas Company, Charleston, W. Va.; H. D. Freeland, Waynesburg, Pa.; Samuel Brendel, Brendel Producing Company, Pittsburgh; Sam S. Keenan, Carnegie Natural Gas Company, Pittsburgh; S. P. Hartson, Equitable Gas Company, Pittsburgh; Thomas H. Kerr, Ohio Fuel Gas Company, Columbus, Ohio; R. N. Parks, Virginian Gasoline & Oil Company, Charleston, W. Va.

District No. 2: Burt R. Bay, Northern Natural Gas Company, Omaha, chairman; A. W. Ambrose, Cities Service Gas Company, Bartlesville; Frank B. Long, Oklahoma Natural Gas Company, Tulsa; E. V. Kesinger, Natural Gas Pipeline Company of America, Chicago; W. C. Taggart, Taggart Bros., Inc., Big Rapids, Mich.; C. S. Sanders, Stanolind Oil & Gas Company, Tulsa; Edward Buddrus, Phillips Petroleum Company, Bartlesville; Joseph A. La Fortune, Warren Petroleum Corporation, Tulsa; M. M. Stalcup, Skelly Oil Company, Tulsa; T. J. Strickler, Kansas City Gas Company, Kansas City.

District No. 3: Neil C. McGowan, United Gas Pipe Line Company, Shreveport, chairman; R. E. Wertz, Amarillo Gas Company, Amarillo; Paul Kayser, El Paso Natural Gas Company, El Paso; C. Pratt Rather, Southern Natural Gas Company, Birmingham; E. F. Schmidt, Lone Star Gas Company, Dallas; Ted Goebel, Shell Oil Company, Houston; J. H. Boyle, Hanlon-Buchanan Gasoline Company, Tulsa; Clyde Alexander, Dallas; Lawrence R. Hagy, Amarillo; J. H. Dunn, Shamrock Oil & Gas Corporation, Amarillo.

District No. 4: Robert W. Hendee, Colorado-Interstate Gas Company, Colorado Springs; Cecil W. Smith, Montana-Dakota Utilities Company, Minneapolis; J. H. McIntire, Northern Utilities Company, Casper; F. T. Parks, Public Service Company of Colorado, Denver; R. D. Smith, Glacier Production Company, Butte, Mont.; J. D. Roberts, Mountain Fuel Supply Company, Salt Lake City; E. B. Coolidge, Hard Rock Oil Company, Great Falls, Mont.; J. C. Johnston, Continental Oil Company, Denver; John T. Bishop, Basin, Wyo.

District No. 5: William Noeller, Southern California Gas Company, Los Angeles, chairman; George F. Schroeder, Standard Oil Company of California, San Francisco; E. H. McCollough, Amerada Petroleum Corporation, Los Angeles; A. F. Bridge, Southern Counties Gas Company, Los Angeles; W. G. Vincent, Pacific Gas & Electric Company, San Francisco; H. L. Farrar, Coast Counties Gas Company, San Francisco; R. H. Green, Signal Oil & Gas Company, Los Angeles; H. L. Eggleston, Gilmore Oil Company, Los Angeles; H. R. Linhoff, Richfield Oil Corporation, Los Angeles; L. V. Cassady, Lomita Gasoline Company, Long Beach.

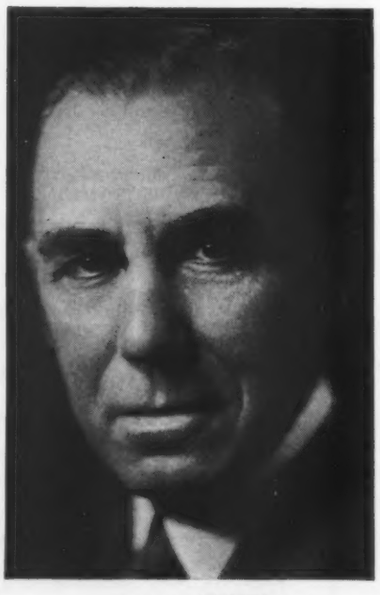
E. R. Brown, Texas Pioneer Refiner, Dies in New York

E. R. Brown, chairman of the board of directors of Magnolia Petroleum Company and a vice president of Socony-Vacuum Oil Company, died January 25 in New York. He supervised construction of the first refining plant in Texas and became superintendent of the unit of J. S. Cullinan Company at Corsicana. It was around this plant that Magnolia Petroleum Company finally was organized.

Since 1914 he had lived in Dallas, where he was a leader in civic and commercial affairs. His many contributions to the life of Southwest were honored by the Mid-Continent Oil & Gas Association in 1940, when he was singled out for distinguished services.

Brown was a native of Little Hocking, Ohio, where he was born in 1868. After graduation from Marietta College in 1894 he went to work in the Olean plant of Standard Oil Company of New York as a yard man. He had advanced to assistant superintendent of the plant when he came to Corsicana in 1898 to supervise construction of the venture by J. S. Cullinan. Three years later the concern became Corsicana Refining Company and Brown was elected manager. Successively the concern was Navarro Refining Company, John Sealy & Company and Magnolia Petroleum Company, which was organized in 1911, with Brown as vice president.

He was elected president of Magnolia Petroleum Company in 1924 and in 1933 was elevated to chairman of the board of both Magnolia Petroleum Company and Magnolia Pipe Line Company. Two years later he was elected a vice president of Standard Oil Company of New York and after its merger with Vacuum Oil Company he became a director as well as vice president of Socony-Vacuum Oil Company.



E. R. BROWN

Aviation Gasoline Control Changes

Amendments have been made to Recommendation No. 16, which centralizes control of aviation gasoline in the Office of the Petroleum Coordinator. The amendments were made to simplify and speed administration of the recommendation without sacrificing its important provisions. The changes are given below:

"Section 1504.15 now requires that a statement of the terms of all contracts and agreements for the production, storage, use, sale, or other disposition of aviation gasoline, base stocks, and blending agents be filed in this office. The amendment to this section would relieve from this requirement contracts and agreements with respect to production.

"The reason for this amendment is that the refining division already has information concerning the more important production contracts and does not wish to have to handle or to burden the industry with the preparation of statements concerning hundreds of small and relatively unimportant contracts.

"Section 1504.16 now requires antecedent notice of all action hereafter taken with respect to aviation gasoline, base stocks, and blending agents. The amendment relieves from this requirement action taken with respect to the production or storage of aviation gasoline, base stocks, and blending agents, and provides instead for subsequent notice thereof.

"This amendment is considered necessary in order that there be no possibility of delay in increasing the production and storage of such materials. The amendment to this section also excepts from its provisions aviation gasoline of 85-octane rating or less produced by the addition of tetraethyl lead to a clear base stock of not more than 67-octane rating. The refining division considers the information unnecessary with respect to this type of gasoline. Further, in order to provide for the immediate handling of emergency deliveries to the War and Navy departments, the amendment provides for subsequent rather than antecedent notice thereof.

"The amendment to Section 1504.17 permits the holding of joint meetings of committees from different districts for the purpose of drafting plans for increasing the output of aviation gasoline where it is necessary or desirable that such plans cover more than one district."

Oil Will Supply Synthetic Rubber

An outline of the part the petroleum industry will play in providing base materials for synthetic rubber production has been given by Robert H. Colley, president of The Atlantic Refining Company, as follows:

"When the United States is freed of its dependence upon natural rubber imported from overseas, it will owe no small part of this freedom to the American petroleum industry. Germany now manufactures a synthetic rubber, but our industrial chemists are ready to duplicate this rubber here for less than it costs to manufacture in Germany by using petroleum or natural gas as a base. As a result, the national government, in cooperation with the

fifty years of Mathieson Chemicals

An American Pioneer FACES THE FUTURE

● Fifty years ago, when Mathieson was established, all of the bleaching powder and most of the alkali used in this country were imported from England. Since 1892, when Mathieson began pioneering the domestic manufacture of these and other products, its original plant at Saltville, Va., has grown into three modern manufacturing units covering hundreds of acres of ground.

In the laboratory, in the plant and in the field, Mathieson chemists and engineers have been leaders in research and in the development of new products . . . in the adaptation of both new and old products to more efficient use in industry . . . in the modern transportation and low-cost distribution of chemicals direct to the consumer.

Today, the towering stacks of three great Mathieson plants are dynamic evidence of a half a century of progress in the production and distribution of quality chemicals. Strategically located at Saltville, Niagara Falls and Lake Charles, Louisiana, these three manufacturing units are in a position to serve consumers of alkali and chlorine products throughout the chief industrial areas of the country.

In 1942, on its 50th Anniversary The Mathieson Alkali Works is proud to rededicate its plants and personnel to a nation at war . . . confident that the vision and initiative which have made America strong will win through to victory.

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CELEBRATING FIFTY YEARS OF SERVICE TO AMERICAN INDUSTRY AND PUBLIC HEALTH

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rubber industry and the petroleum industry, is preparing to embark upon a most ambitious program for the manufacture of such rubber. The new facilities which are to be built are designed to yield, by the middle of next year, an annual production of 400,000 tons of synthetic rubber. This will be sufficient to satisfy all military requirements, and most imperative civilian needs as well."

Colley said the part petroleum is to play in the production of synthetic rubber illustrates the almost universal role petroleum has in the nation's economy.

"Because the rapid growth of the petroleum industry has paralleled the rise of motorized transportation both on land and in the air, it is natural to think of the industry primarily in connection with the automobile and the airplane," Colley explained. "But it is also true that oil today flows through all the industrial arteries of the world. It turns the wheels or provides the lubrication for every machine that moves. It heats many of our homes and other buildings. It is the source of materials that enter into the fabrication of countless commodities that play a part in our everyday lives.

"Such substances as benzine, toluene, xylene, and other substances used in the manufacture of dyes are produced from gases created in the refining process. Many of these materials are used also today in the manufacture of explosives. The gases which supply these materials also are the source of resins which are manufactured today into a whole group of new plastics and rubber-like materials which are resistant to acids and alkalies. Fine lacquers contain petroleum solvents which hold the paints in suspension. Most of the asphalt used in the construction of highways is a petroleum product.

"Petroleum products also enter into the manufacture of linoleum, soap, candles, and many pharmaceuticals. Certain oils are used for treating wool. Petroleum waxes are essential in the manufacture of various kinds of paper. Sulphuric acid, and methyl, ethyl, and other alcohols, are being produced from petroleum or petroleum gases. Both electric cables and power transformers depend for insulation on highly processed petroleum products. In fact, petroleum today is probably the most important single raw material in the nation's economy."

High Pressure Tank Cars Needed

Need for more tank cars of pressure rating to handle movement of isobutane to 100-octane gasoline plants has brought a survey of existing equipment under direction of the Office of the Petroleum Coordinator. Together with the Interstate Commerce Commission, the Association of American Railroads and owners of tank cars, an effort is being made to determine the possibility of converting ordinary tank cars to natural gasoline service, while natural gasoline cars will be converted to such uses as isobutane transportation. The situation has been summed up in this release from the Office of the Petroleum Coordinator:

"Part of the demand for cars can be met by eliminating cross-hauls and back-hauls, by reducing the number of distribution points and by speeding up turn-arounds. Action in this direction may be expected, with a view to handling normal business with fewer cars and freeing immediately for special defense service a number of the right kind of cars.

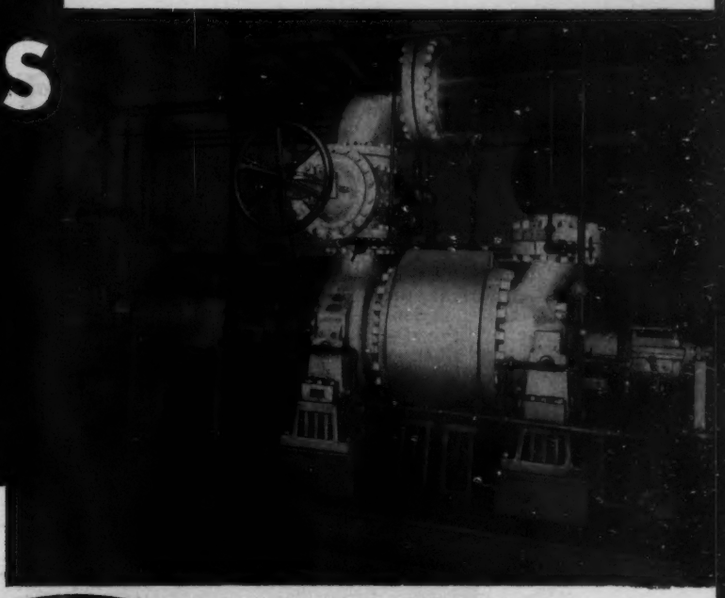
"In connection with the relief which might be obtained by converting cars, the Coordinator's office has recognized the possibility that existing cars very probably have been built stronger and heavier than actually necessary for the service in which they are engaged now.

"The preliminary inquiry bears this out. It has developed the definite possibility of converting insulated asphalt or road-oil cars for transportation of natural gasoline, and, in turn, converting natural gasoline cars for normal butane service, and, possibly, for the hauling of butadiene. Cars in normal butane and butadiene services then would be released for handling isobutane.

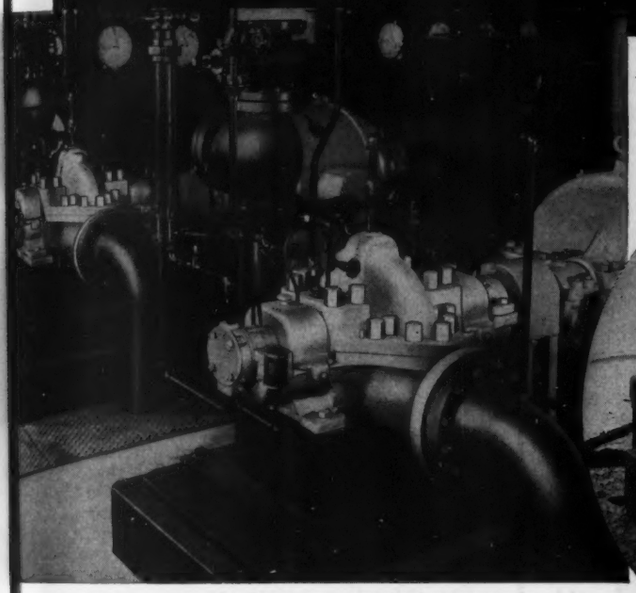
"Safety and other regulations require, however, that nothing be left to chance. Consequently, a series of careful tests of all the various types of cars is being arranged for the purpose of determining those which can be converted safely to carry liquefied gases of various pressures.

"Three companies will make the tests. From each of several car classifications, they will select those with tanks which are sufficiently heavy to permit higher safety-valve settings and on these install

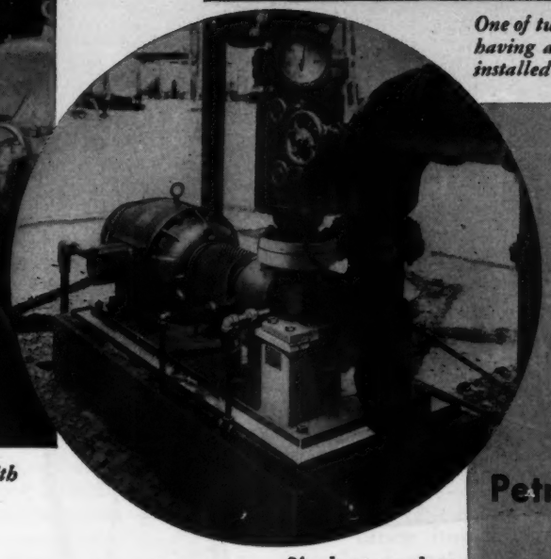
REFINERY PUMPS THAT STAY ON THE JOB



One of two cracking-coil charging pumps having a capacity of 1400 gal per min installed in a large refinery.



Single-stage class JVL pumps charging a debutanizer with cracked distillate.



Single-stage class SFL pump serving a stabilizer.

- Dependable operation is of major importance in refinery pumps. Our wide experience in this field, and unexcelled manufacturing, metallurgical and research facilities, enable us to produce pumps that stay on the job.

Ingersoll-Rand pumps are successfully serving refineries of all sizes from 30 to 140,000 bbls. per day capacity. No matter what the service, whether it is handling water, butane, distillates, solvents, propane, gasoline, hot or cold oil or other refinery liquids, there is an I-R pump exactly suited to your needs.

The Ingersoll-Rand line includes a complete range of sizes and types of refinery pumps. Let our engineers help you with your problems.

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the necessary fittings and safety devices needed to make them suitable for handling butane. Upon conversion, trial service certificates will be sought from the Interstate Commerce Commission and test runs made to determine what series of cars can safely be converted to handle higher pressure gases than those for which constructed.

"At present there are about 1200 cars in the liquefied gas service, with a few additional building. There are some 1800 others which meet the rigid requirements, but these, it is recognized, are already operating in other essential services — hauling chlorine, anhydrous ammonia, sulphur dioxide, etc. — and therefore are not available."

Chemical Warfare Service Needs

Help from the oil industry to provide trained operators for chemical warfare service is sought by the government. Pointing out that the Chemical Warfare Service is rapidly expanding, Brigadier General R. C. Ditto, of the Huntsville Arsenal in Alabama, declares several hundred operators are needed at that arsenal alone. General Ditto is asking the oil companies to publicize this need.

In a letter to the American Petroleum Institute he declares, "It is felt the American Petroleum Institute could render . . . a service to the country by calling to the attention of its members the open competitive examinations for chemical plant operators, chemical plant workmen and foremen. . . . Higher ratings are also available to those qualified."

Minimum experience requirements for the lowest classification, that of plant workman, are: six months operating chemical plant equipment, or successful completion of a Defense Training Course in vocational level chemistry, or completion of one year of a course in chemistry or chemical engineering including at least eight semester hours of general chemistry. Requirements for other classifications are similar but correspondingly advanced. Forms and additional information may be obtained from civil service examiners' boards at the Huntsville arsenal or the post office at Huntsville, Ala., or Atlanta, Ga. The pay scale ranges from $5.28 to $10 per day, with provisions for overtime.

Committee Seeks Butane Information

Following establishment of offices for District 3 in the Mellie Esperson Building, Houston, N. C. McGowen, chairman of the Natural Gas and Natural Gasoline committee under OPC, announced that questionnaires had been sent to all plant owners to get information on the status of pentane, propane and butane, which will be required for both the aviation gasoline program as well as that for the production of synthetic rubber.

"In order to assure the greatest possible production of all grades of aviation gasoline, and also for production of synthetic rubber, it is essential that there be maximum production of those products which are necessary in their manufacture such as butane, isobutane, and isopentane," McGowen stated.

"Existing and proposed natural gasoline extraction plants, cycling, pressure-maintenance and repressuring plants are prime sources of butane, isobutane and isopentane and should be so constructed and operated as to facilitate the recovery of these elements in as large quantities as possible."

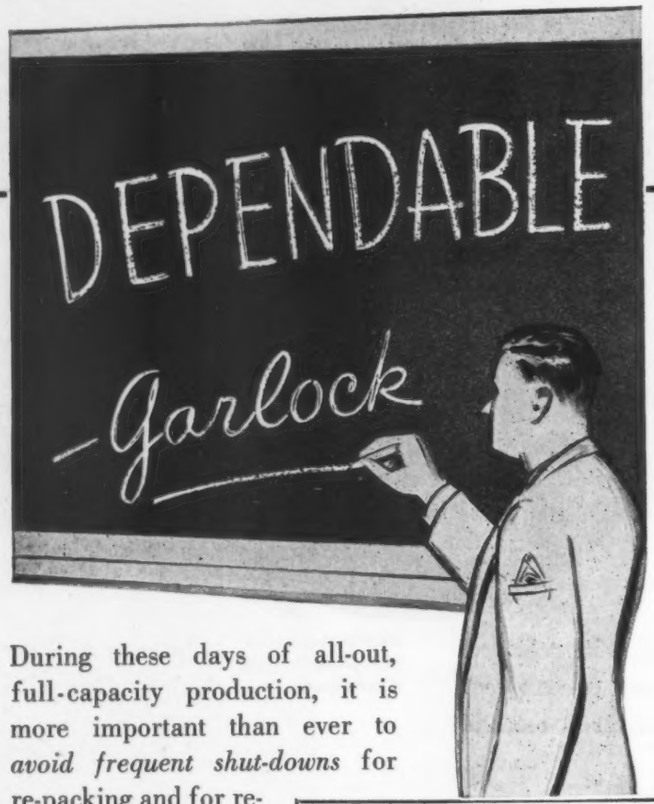
Owners of plants manufacturing these three components of aviation gasoline and synthetic rubber, whether as products or by-products, are being requested to increase their production to the maximum quantity economically possible. Persons or companies planning new plants have been requested to design and construct these plants so as to make the greatest use of scarce materials and to provide for the most efficient extraction of these vital elements.

Oil Price Schedule To Be Released

Prices for petroleum and petroleum products now generally effective as a result of OPA requests and voluntary agreements with members of the industry will be incorporated into a formal price schedule in the near future, Leon Henderson, Administrator of the Office of Price Administration, has announced.

The schedule will follow closely the general letter to the industry sent from OPA on January 17, establishing maximum prices for refined petroleum products at levels prevailing on November 7, 1941, and for crude oil at prices prevailing on October 1, 1941.

Excluded from the schedule will be



During these days of all-out, full-capacity production, it is more important than ever to *avoid frequent shut-downs* for re-packing and for replacement of gaskets. *Standardize on GARLOCK* and be sure of long, dependable service.

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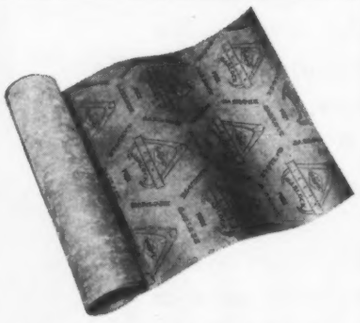

One of the many popular Garlock products — 7021 Compressed Asbestos Sheet Packing. Thicknesses from 1/64" to 1/4". Sheets 40" x 40" and larger.

INCREASE EFFICIENCY

Increase **THROUGH PUT** ➡ **10%**

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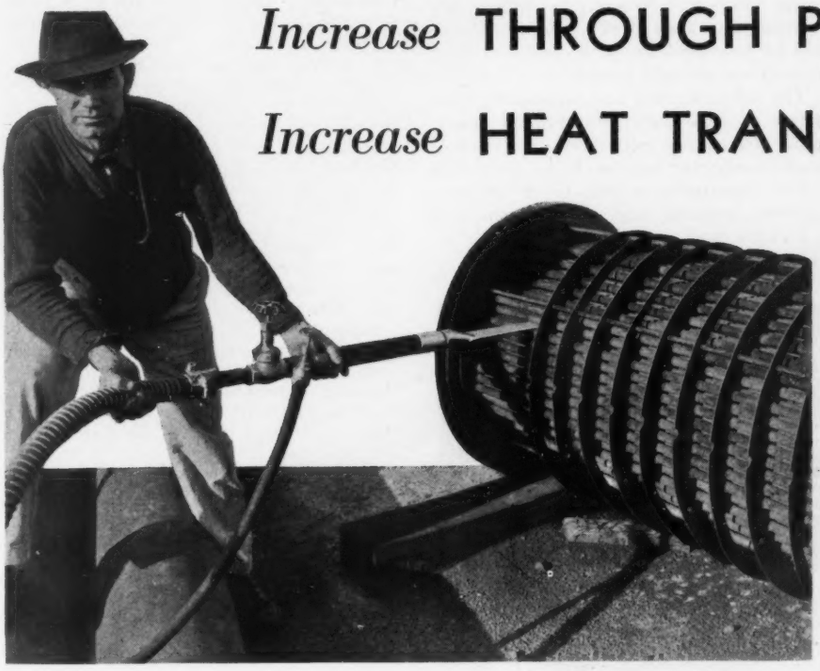
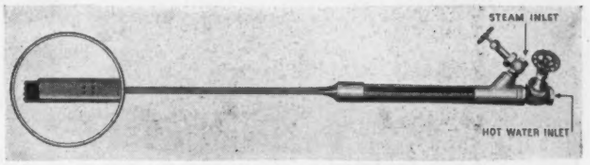


10% more throughput . . . 20% greater heat transfer . . . these are typical results obtained by properly cleaning heat exchanger bundles with the new Airetool Cleaning Lance and other Airetool Tube Cleaning equipment.

Deposits can be removed from points that are usually inaccessible. Airetool's Heat Exchanger Bundle Cleaning Lance can be used in all cases where tubes have a square pitch. The usual space between these tubes being a minimum of ¼". The effective length of the lance is 30" and it may be inserted into the bundle from either side.

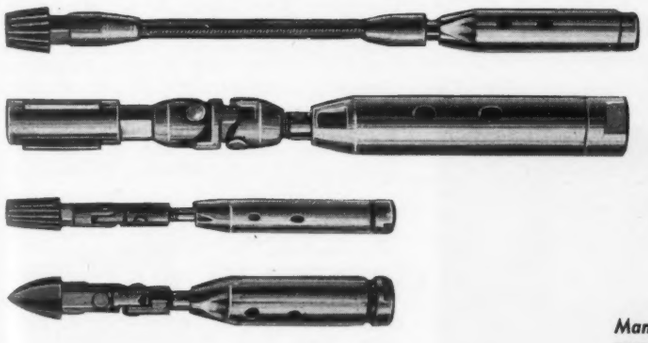
Hot water or a chemical solution is supplied through the 1" main valve and steam through the ½" valve



on the side. A jet in the "Y" fitting mixes them properly. The lance handle is insulated so as to fully protect the operator.

You need this tool to keep your heat exchangers operating at top efficiency. Write for further details.

TUBE CLEANING TOOLS



Shown at the left are several of the various types of Airetool Tube Cleaners for small tubes. Cleaners shown are for lightly scaled tubes from ½" I.D. to 1⅜" I.D. Others are made for heavily scaled tubes. These small Airetool Tube Cleaners are for Heat Exchangers, Condensers, Air Coolers, Air Preheaters, Reboiler Tubes and Small Diameter Pipe Coils. Other Airetool Tube Cleaners are made in sizes up to 20" I.D. Details sent on request.

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Please send complete information on items checked. ☐ Cleaning Lance. ☐ Small Tube Cleaners. ☐ Large Tube Cleaners. ☐ Refinery Tools.

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carbon-black prices, which are governed by existing agreements made upon request of OPA. With this exception the effect of the schedule will be to formalize existing relationships between the Office of Price Administration and the petroleum industry.

In addition to setting maximum prices for petroleum and petroleum products generally, the price schedule will make provisions to cover the special situation in 15 Eastern and Southern states and the District of Columbia, where recently a 3/10 cent per gallon increase in gasoline was permitted because of increased carrying charges incurred by producers to avert a gasoline shortage due to diversion of tankers to war and lend-lease use.

Exceptions will be made to cover the Bunker C and Grade 6 fuel oil prices on the Eastern Seaboard and Gulf Coast, recently established in a price schedule.

Special tank-wagon situations in Iowa, Ohio and Wisconsin, and in the metropolitan area of Washington, D. C., will be provided for in accordance with allowances already issued by OPA.

The schedule will not necessarily constitute a final determination of maximum prices for petroleum and petroleum products, inasmuch as extensive OPA investigations into crude oil production, refining and distribution still are under way.

Check these advantages of

LIGHTWEIGHT WALLS

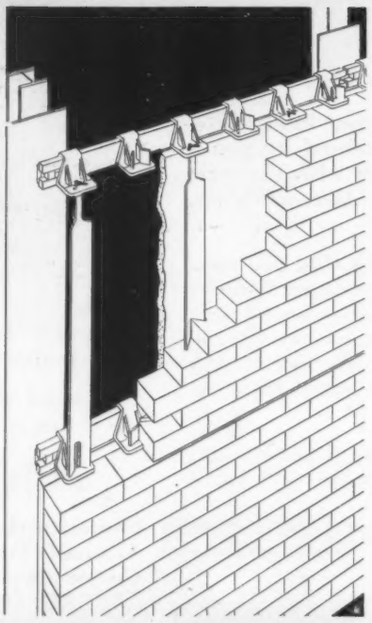
before you build a cracking furnace

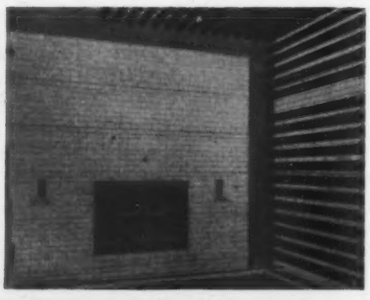
MORE than *sixty* lightweight cracking unit furnaces are now in service—many of them *repeat* purchases. Shown here is a sectionally supported visbreaker wall (designed by M. W. Kellogg Co., N. Y. C.)—one of the simple, economical, yet highly efficient, lightweight constructions possible with Armstrong's Insulating Fire Brick.

These brick have 3 times the insulating efficiency of fire brick with only ⅓ the weight. Thus thin, light walls of Armstrong's Brick are more effective than ordinary walls and are built with much lighter, less costly supports and foundations.

Armstrong's Refractories are easily cut, bored, and slotted right on the job. Hence no large inventories of special shapes are needed for repairs and replacements. In this Kellogg Wall, standard shapes are used throughout. Castings are placed between the block insulation and the brick to minimize heat leakage. Walls heat and cool quicker because of their low heat storage.

All these construction and operating advantages, plus impressive records in service, account for the growing trend to lightweight units in the refinery field. For facts about lightweight Armstrong's Brick write to Armstrong Cork Company, Insulating Refractories Department, 1001 Concord St., Lancaster, Pennsylvania.





ARMSTRONG'S INSULATING REFRACTORIES

API Divisional Committees Are Appointed for 1942

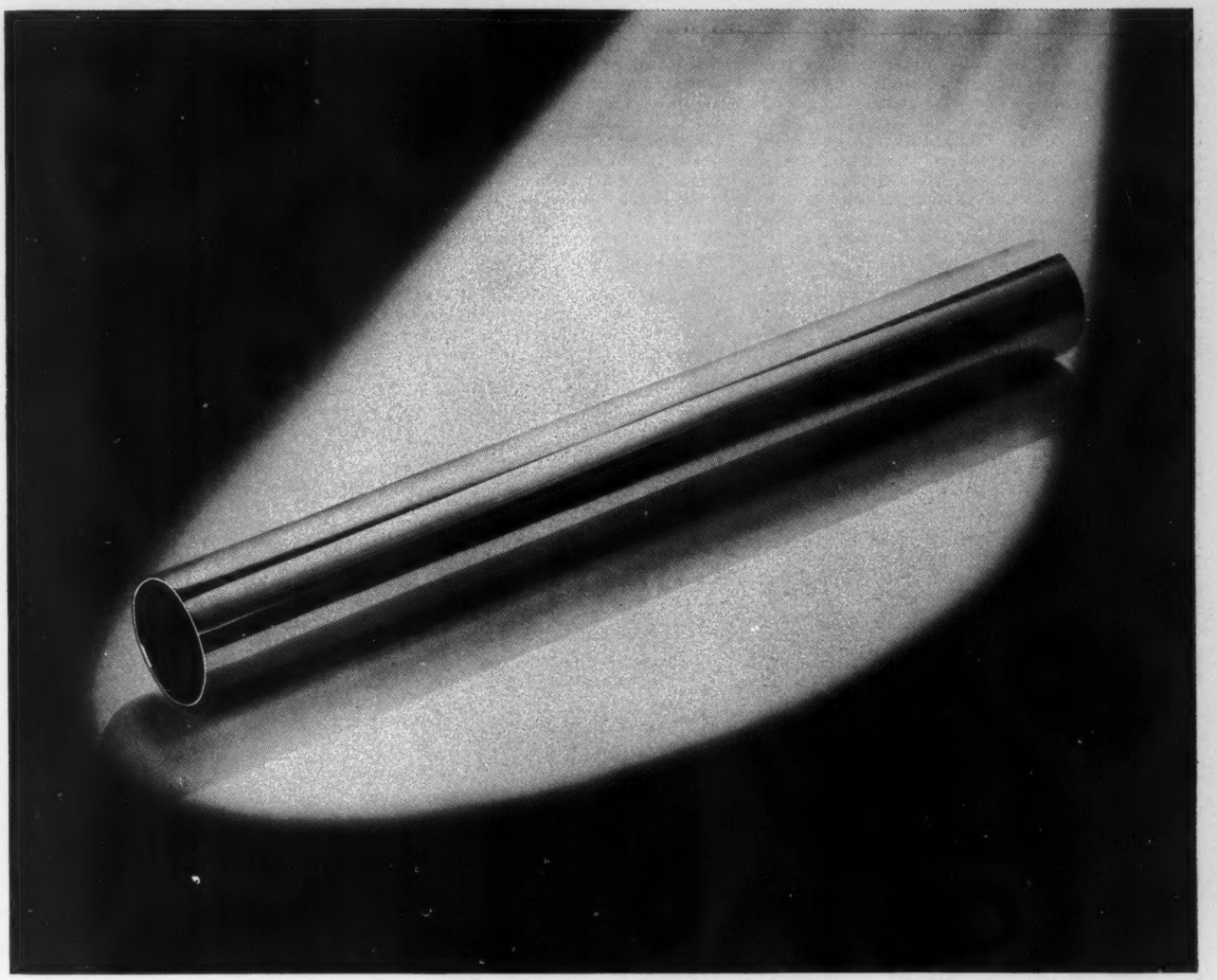
Chairman J. Howard Pew, of the American Petroleum Institute General Committee of the Division of Refining, has appointed the Central Committee on Refinery Technology and the Program Committee for 1942. The committees follow:

Central Committee on Refinery Technology: Chairman, T. G. Delbridge, The Atlantic Refining Company, Philadelphia; Secretary, R. P. Anderson. Members: Bruce K. Brown, Standard Oil Company (Indiana), Chicago; H. W. Camp, Cities Service Oil Company, Bartlesville; F. S. Clulow, Shell Oil Company, San Francisco; L. L. Davis, Continental Oil Company, Ponca City; David E. Day, Richfield Oil Corporation, Los Angeles; B. C. Frichot, Deep Rock Oil Corporation, Cushing, Okla.; R. A. Halloran, Standard Oil Company of California, San Francisco; Basil Hopper, Union Oil Company of California, Los Angeles; E. W. Isom, Sinclair Refining Company, New York; N. E. Loomis, Standard Oil Development Company, New York; K. G. Mackenzie, The Texas Company, New York; E. B. McConnell, The Standard Oil Company (Ohio), Cleveland; John T. McCoy, Tide Water Associated Oil Company, Bayonne; F. W. McCurry, Derby Oil Company, Wichita; A. E. Pew, Jr., Sun Oil Company, Philadelphia; R. H. Price, Pan American Petroleum and Transport Company, Texas City; J. B. Rather, Socony-Vacuum Oil Company, New York; W. F. Sims, Panhandle Refining Company, Wichita Falls; Herschel G. Smith, Gulf Oil Corporation, Philadelphia; C. R. Wagner, The Pure Oil Company, Chicago; H. D. Wilde, Humble Oil & Refining Company, Houston; and M. P. Youker, Phillips Petroleum Company, Bartlesville.

Program Committee: Chairman, C. R. Wagner, The Pure Oil Company, Chicago; Secretary, R. P. Anderson. Members: H. W. Camp, Cities Service Oil Company, Bartlesville; F. S. Clulow, Shell Oil Company. San Francisco; T. G. Delbridge, The Atlantic Refining Company, Philadelphia; R. A. Halloran, Standard Oil Company of California, San Francisco; J. Bennett Hill, Sun Oil Company, Marcus Hook; Basil Hopper, Union Oil Company of California, Los Angeles; E. W. Isom, Sinclair Refining Company, New York; N. E. Loomis, Standard Oil Development Company, New York; K. G. Mackenzie, The Texas Company, New York; Walter Miller, Continental Oil Company, Ponca City; G. G. Oberfell, Phillips Petroleum Company, Bartlesville; J. B. Rather, Socony-Vacuum Oil Company, New York; J. K. Roberts, Standard Oil Company (Indiana), Chicago; and Herschel G. Smith, Gulf Oil Corporation, Philadelphia.

T. G. Delbridge, chairman of the Central Committee on Refinery Technology, has appointed the following committees to serve during 1942:

Automotive Research Committee: Chairman, K. G. Mackenzie, The Texas Company, New York; Secretary, R. P. Anderson. Members: D. P. Barnard, Standard Oil Company (Indiana), Whiting; D. E. Carr, Union Oil Company of California, Wilmington; C. E. Davis, Shell Oil Company, New York; G. H. B. Davis, Esso Laboratories, Elizabeth, N. J.; T. G. Delbridge, The Atlantic Refining Company, Philadelphia; P. D. Foote, Gulf Research and Development Company, Pittsburgh; R. A. Halloran, Standard Oil Company of California, San Francisco; E. W. Isom,



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It is produced by a closely controlled electric welding process that gives it unusually smooth finish — "flash" is hardly detectable. Gloweld's light weight, high resistance to corrosion, heat and pressure, comparatively lower cost, and other advantages will find many applications for tubing in chemical and process industries, food industries, pulp and paper, oil and other industries where these factors are needed. It is already in use in aircraft construction — as hydraulic lines, for frame and engine parts. Available in a wide range of diameters and wall sizes, in practically all stainless steel analyses. Write for full information.

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Automotive Survey Division of the Automotive Research Committee (appointed by K. G. Mackenzie, chairman, Automotive Research Committee): Chairman, A. Ludlow Clayden, Sun Oil Company, Marcus Hook; Secretary, R. P. Anderson. Members: W. G. Ainsley, Sinclair Refining Company, East Chicago; R. C. Alden, Phillips Petroleum Company, Bartlesville; D. P. Barnard, Standard Oil Company (Indiana), Whiting; A. J. Blackwood, Esso Laboratories, Elizabeth, N. J.; K. Boldt, The Pure Oil Company, Chicago; F. C. Burk, The Atlantic Refining Company, Philadelphia; C. W. Butler, Gulf Research and Development Company, Cheswick, Pa.; D. E. Carr, Union Oil Company of California, Wilmington; D. E. Day, Richfield Oil Corporation, Los Angeles; W. N. Fenney, The Texas Company, New York; A. P. Frame, Cities Service Oil Company, New York; L. E. Hebl, Shell Oil Company, Wood River; W. M. Holaday, Socony-Vacuum Oil Company, New York; J. R. MacGregor, Standard Oil Company of California, Richmond; E. B. McConnell, The Standard Oil Company (Ohio), Cleveland; L. Raymond, Tide Water Associated Oil Company, Bayonne; and B. E. Sibley, Continental Oil Company, Ponca City.

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Committee on Corrosion of Refinery Equipment: Chairman, L. L. Davis, Continental Oil Company, Ponca City; Secretary, D. V. Stroop. Members: C. C. Ashley, Shell Oil Company, San Francisco; A. B. Bagsar, Sun Oil Company, Marcus Hook; W. H. Bahlke, Standard Oil Company (Indiana), Whiting; F. B. Bluhm, Sinclair Refining Company, East Chicago; F. C. Braun, Gulf Oil Corporation, Pittsburgh; E. Q. Camp, Humble Oil & Refining Company, Baytown; E. S. Dixon, The Texas Company, Port Arthur; L. M. Goldsmith, The Atlantic Refining Company, Philadelphia; J. W. Griswold, Cities Service Oil Company, Philadelphia; A. E. Harnsberger, The Pure Oil Company, Chicago; Basil Hopper, Union Oil Company of California, Los Angeles; K. V. King, Standard Oil Company of California, San Francisco; L. D. Mann, Cities Service Oil Company, Tulsa; F. L. Newcomb, Standard Oil Development Company, Elizabeth, N. J.; J. W. Newton, Magnolia Petroleum Company, Beaumont; R. Stanfield, Tide Water Associated Oil Company, Bayonne; H. F. West, The Standard Oil Company (Ohio), Cleveland; and M. P. Youker, Phillips Petroleum Company, Bartlesville.

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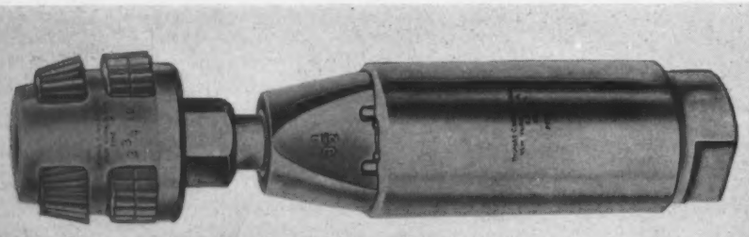

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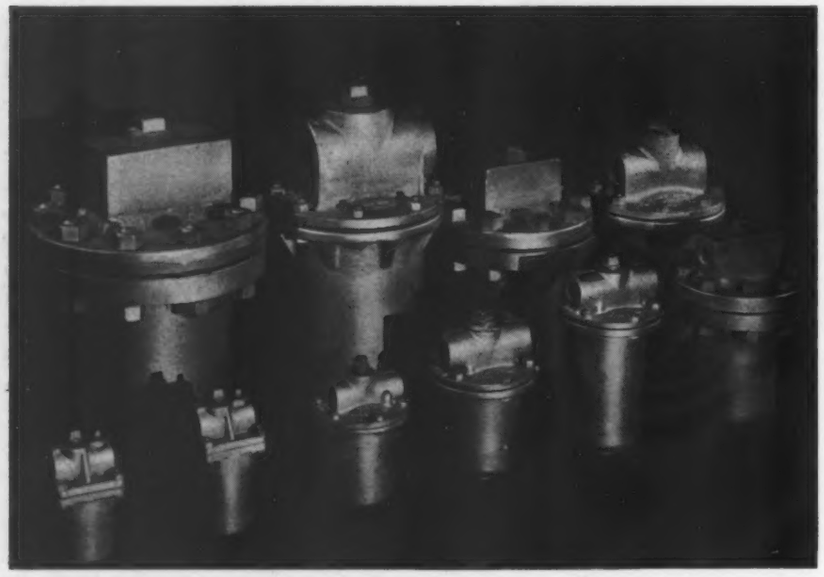

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New Book on Welding Training

A new book prepared primarily to assist instructors in planning courses for the training of oxy-acetylene welding and cutting operators has just been published by the International Acetylene Association. The book, "Training Oxy-Acetylene Welding and Cutting Operators — Instructors Outlines," is divided into three chapters. The first

Defense Savings Pay-Roll Allotment Plan

How company heads can help their country, their employees, and themselves

voluntary pay-roll allotment plan | **helps** workers provide for the future; **helps** build future buying power; **helps** defend America today

This is no charity plea. It is a sound business proposition that vitally concerns the present and future welfare of your company, your employees, and yourself.

During the post-war period of readjustment, you may be faced with the unpleasant necessity of turning employees out into a confused and cheerless world. But you, as an employer, can do something *now* to help shape the destinies of your people. Scores of business heads have adopted the Voluntary Pay-roll Allotment Plan as a simple and easy way for every worker in the land to start a *systematic* and *continuous* Defense Bond savings program.

Many benefits . . . present and future. It is more than a sensible step toward reducing the ranks of the post-war needy. It will help spread financial participation in National Defense among all of America's wage earners.

The wider spread use of this plan will materially retard inflation. It will "store" part of our pyramiding national income that would otherwise be spent as fast as it's earned, increasing the demand for our diminishing supply of consumer goods.

And don't overlook the immediate benefit . . . money for defense materials, quickly, continuously, *willingly.*

Let's do it the American way! America's talent for working out emergency problems, democratically, is being tested today. As always, we will work it out, without pressure or coercion . . . in that old American way; each businessman strengthening his *own* house; not waiting for his neighbor to do it. That custom has, throughout history, enabled America to get things done *of its own free will.*

In emergencies, America doesn't do things "hit-or-miss." We would get there *eventually* if we just left it to everybody's whim to buy Defense Bonds when they thought of it. But we're a nation of businessmen who understand that the way to get a thing done is to *systematize* the operation. That is why so many employers are getting back of this Voluntary Savings Plan.

Like most efficient systems, it is amazingly simple. All you have to do is offer your employees the convenience of having a fixed sum allotted, from each pay envelope, to the purchase of Defense Bonds. The employer holds these funds in a separate bank account, and delivers a Bond to the employee each time his allotments accumulate to a sufficient amount.

Each employee who chooses to start this savings plan decides for himself the denomination of the Bonds to be purchased and the amount to be allotted from his wages each pay day.

How big does a company have to be? From three employees on up. Size has nothing to do with it. It works equally well in stores, schools, publishing houses, factories, or banks. This whole idea of pay-roll allotment has been evolved by businessmen in cooperation with the Treasury Department. Each organization adopts its own simple, efficient application of the idea in accordance with the needs of its own set-up

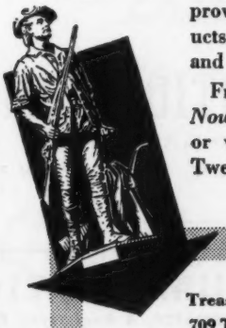
No chore at all. The system is so simple that A. T. & T. uses exactly the same easy card system that is being used by hundreds of companies having fewer than 25 employees! It is simple enough to be handled by a check-mark on a card each pay day.

Plenty of help available. Although this is *your* plan when you put it into effect, the Treasury Department is ready and willing to give you all kinds of help. Local civilian committees in 48 States are set up to have experienced men work with you just as much as you want them to, and no more.

Truly, about all *you* have to do is to indicate your willingness to get your organization started. We will supply most of the necessary material, and no end of help.

The first step is to take a closer look. Sending in the coupon in no way obligates you to install the Plan. It will simply give you a chance to scrutinize the available material and see what other companies are already doing. It will bring you samples of literature explaining the benefits to employees and describing the various denominations of Defense Savings Bonds that can be purchased through the Plan.

Sending the coupon does nothing more than signify that you are anxious to do *something* to help keep your people off relief when defense production sloughs off; *something* to enable *all* wage earners to participate in financing Defense; *something* to provide tomorrow's buying power for your products; *something* to get money *right now* for guns and tanks and planes and ships.



France left it to "hit-or-miss" . . . and *missed. Now* is the time for *you* to act! Mail the coupon or write Treasury Department, Section A, 709 Twelfth St. NW., Washington, D. C.

FREE - NO OBLIGATION

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Please send me the free kit of material being used by companies that have installed the Voluntary Defense Savings Pay-Roll Allotment Plan.

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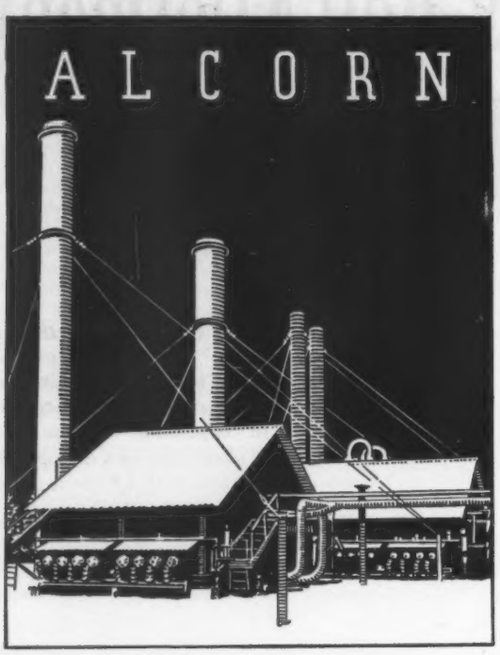

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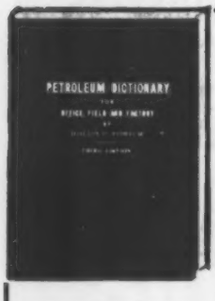

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This book grew out of demands for some source of definitions for terms used by the petroleum industry. Previous editions have gone into the hands of executives, engineers, students of Petroleum Engineering, manufacturers, brokers and advertising agencies. It should be in the library of every one in any way connected with, or interested in the petroleum industry.

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outlines the essential information that should be presented in a course for the training of a general welding operator, an aircraft-welding operator, and a pipe-welding operator. The second chapter contains in outline form the material that is essential to the training of various types of cutting operators. The third chapter outlines the essential information that should be given in a course for inspectors and a specification of the primary requirements of students who take the inspector's course. Furthermore, these outlines furnish the basis for many other types of specialized courses, and suggestions for completing these are included in the book.

The material presented throughout the book has been divided into self-contained units, each of which includes the four essential parts of any particular lesson, namely, an outline for a classroom lecture, suggestions for study assignments, recommendations for the material that should be demonstrated and discussed, and a description of the practice exercises the student should do in the shop. Recommendations for qualitative testing of the work done are included throughout the book. An introduction describes in considerable detail the organization of the book and gives suggestions for its use.

Copies of this new 88-page book can be obtained by writing to the Secretary of the International Acetylene Association, 30 East Forty-second Street, New York. Paper-bound copies are 25 cents each. A de luxe edition, cloth-bound, has also been prepared and can be obtained for 75 cents a copy.

Anti-Knock Rating Up In 1941 Survey

Octane rating of the three grades of motor fuel sold in the United States showed further advance in the semi-annual survey, which is now available as Report of Investigations 3611 of the United States Bureau of Mines. An analysis of the survey recently released was:

"Based on analyses of more than 1,800 samples, it was found that the anti-knock rating of regular and premium-priced gasoline dispensed at service stations was slightly higher than that of the previous summer of 1940. In addition, the survey disclosed that the anti-knock and volatility qualities of all three grades of gasoline have shown a steady improvement in the five years since the surveys were inaugurated in 1936.

"Representing the products of approximately 135 companies both large and small, a total of 1,857 samples of gasoline were included in the survey recently completed. The samples, analyzed by the cooperating companies, included 86 brands of gasoline in the regular-price group, 78 in the premium-priced classification, and 74 brands in the third-grade gasoline group.

"During the past five years the average octane rating of regular-price gasoline has risen from 69.6 to 74.7, a gain of 5.1 units. The premium-priced grade has increased 3 units from 77.2 to 80.2, while the third-grade gasoline advanced 6.6 units from 57.3 to 63.9.

"The semi-annual motor gasoline surveys are made by the Bureau of Mines in cooperation with the Cooperative Fuel Research Committee, which

is a joint activity of the Society of Automotive Engineers, the American Petroleum Institute, the Automobile Manufacturers Association, and the National Bureau of Standards."

Oil May Augment Soap Manufacture

Already launched upon a program to produce 400,000 tons yearly of synthetic rubber to replace the natural product, the petroleum industry could also provide the raw materials to make satisfactory soap, at present produced from coconut and other imported oils. Improvements in processes for making soap from petroleum materials were recently announced in New York by Dr. Martin H. Ittner, research director for Colgate-Palmolive-Peet Company.

In the course of an address at the Chemists Club, where he was presented with the Perkin medal for 1942 for his contributions to soap manufacture, he outlined a method of making an acceptable soap from organic acid mixtures derived from petroleum. "These crude acid mixtures," he declared, "are hardly worthy of the designation of 'fatty acids' even though they contain a rather high percentage of real fatty acids. They contain also hydroxy acids and a very considerable amount of lactones, and they make very dark, evil-smelling soap with poor washing qualities.

"A treatment of these petroleum-base soaps with steam agitation well above their anhydrous melting points effects a decided chemical change in the soap, altering the lactone soaps, which do not lather at all well, to soaps of unsaturated fatty acids, which lather exceedingly well. At the same time the odor is improved. Acidification, distillation and reconversion into soap make a usable product."

Canadian Coals Show High Hydrogenation Oil Content

Recent tests carried out at Ottawa by the Department of Mines and Natural Resources to ascertain the suitability of various Canadian coals for producing oil by the hydrogenation process, indicate that coals from several points will be able to produce gasoline, says James Dickson, chief British Columbia inspector of mines.

It was found by these tests that coal from two widely-separated Canadian points—Sydney, N. S., and Nicola, B. C.—give higher yields of oil than standard English coal. The Nicola coal was found to contain 148 gallons of gasoline per ton; the Sydney coal 154 gallons per ton. The English coal mined at Durham contains 143 gallons per ton.

In Canada, however, there are no plants beyond the experimental stage; production of gasoline from coal is a tremendously expensive undertaking.

"On Vancouver Island present indications are that the Comox area will be the chief center of coal production and that while the Nanaimo area will no doubt produce coal for many years it will not again regain its pre-eminence as a coal-producing area," Dickson says.

"The Merritt-Princeton area is capable of producing a large tonnage of coal if markets were available. The East Kootenay coal field has by far the greatest tonnage of coal, both developed and probable, in the established coal mining area of the province."

▼ PLANT ACTIVITIES ▼

With the provision of synthetic rubber base given to the refining industry, its construction program went into the half-million-dollar expenditure class for 1942 and the prospect of a similar amount for 1943. Equipment for synthetic rubber must be added along with the normal expansion, normal maintenance and the augmented 100-octane-aviation-gasoline capacity. The latter is now getting into full swing.

So far no details have been completed on the extent of the synthetic rubber program. It is the plan of the government, however, that oil will be the source material and this is interpreted as assurance that added refining equipment is the only answer. Total expenditure for synthetic rubber is estimated at $400,000,000. Men in the industry have estimated that half the amount will be sufficient for the refining industry, which indicates that half will go into the rubber industry, where finished materials will be made from the output of refining plants.

Surveys are now being made to determine what plants will be used as locations for synthetic rubber base products. Announcements will follow the recent

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policy of censorship in that no mention will be made of exact locations. In general the larger refining plants will be used for its manufacture.

Recent announcements of 100-octane-aviation-gasoline plants adhered to censorship requirements. Both The Pure Oil Company and Southport Petroleum Company have signed contracts for output of this grade of gasoline. In each instance the units will be fully financed by government funds and operated for the government by the companies.

Contracts of other nature have been signed with The Texas Company, Magnolia Petroleum Company, Standard Oil Company of New Jersey, Sun Oil Company, Sinclair Refining Company and Richfield Oil Corporation. Output of all these plants will be bought by an agency of the government.

Censorship requirements also provide that capacities not be made public. Neither will figures be given of actual output of plants whose materials go into military use.

Shell Oil Corporation, already producing war materials on a large scale, has plants under construction to make more and is contemplating still greater construction, according to a company statement. The company is producing butadiene, essential constituent of one type of synthetic rubber, at the rate of several thousand tons a year in a plant built last year. Discussions are under way with the government concerning construction of another large plant.

Several plants for manufacture of toluene, needed to make TNT, are under construction to supplement those already in operation. New plants for manufacture of aviation gasoline will increase Shell's present output of this fuel by nearly 70 percent when completed.

Other construction recently announced within the industry includes the following:

Plant Purchased: Bell Oil & Gas Company, Tulsa, has bought interests of Malco Refineries, Inc., Artesia, New Mexico. Improvements are being made in equipment, which has skimming capacity of 2500 barrels daily and cracking capacity of 1250 barrels daily. Arthur I. Anson, vice president of Bell Oil & Gas Company, is now president of Malco Refineries, Inc.; Robert C. Anderson, formerly with American Mineral Spirits Company, is vice president; Benedict L. Lubell is treasurer.

Plant Expansion: Expansion of facilities of the Aruba plant of Lago Oil & Transport Company will be started by the middle of 1942. Additional cracking capacity and facilities for the manufacture of 100-octane-aviation gasoline are planned. The work is to cost $10,000,000. The Aruba plant is one of the world's largest, 290,000 barrels daily.

Treating Plants: Hanlon Gasoline Company has completed Perco copper sweetening units for its natural-gasoline plants at Breckenridge and McLean, Texas. Each unit has capacity of 40,000 gallons per day. They were designed by Perco Division of Phillips Petroleum Company, Bartlesville, licensor of the process.

Aviation Gasoline: Gulf Refining Company will double its output of 100-octane-aviation gasoline at the Port Arthur plant. Facilities will be installed from designs of Lummus Company at a cost of $3,000,000.

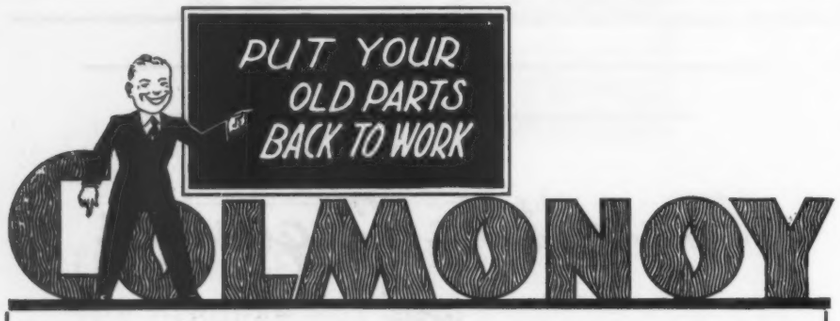
Desulfurization Unit: Col-Tex Refining Company, Colorado City, Texas, will add a 2000-barrel Perco Catalytic Desulfurization unit, which will process straight-run gasoline and distillates including aviation base stocks from West Texas crudes. Commercial-operation and pilot-plant tests have given 94 percent sulphur reduction as well as improved lead susceptibility of these distillates. The plant is being designed by Perco Division of Phillips Petroleum Company.

Toluol Plant: Pan American Refining Corporation will add a toluol unit to its refining plant at Texas City. The process and size of the facilities are now being worked out along with design.

Per K. Frolich to Head ACS in 1943

Per K. Frolich, director of Esso Laboratories, Standard Oil Development Company, Elizabeth, New Jersey, has been chosen president-elect of the American Chemical Society and will take office January 1, 1943. Dr. Henry N. Holmes, Oberlin College, is president for 1942.

Dr. E. R. Weidlein, director of Mellon Institute, Pittsburgh, has been elected a director of the society and Dr. Gustav Egloff, research director of Universal Oil Products Company, Chicago, is a new conciliator-at-large.



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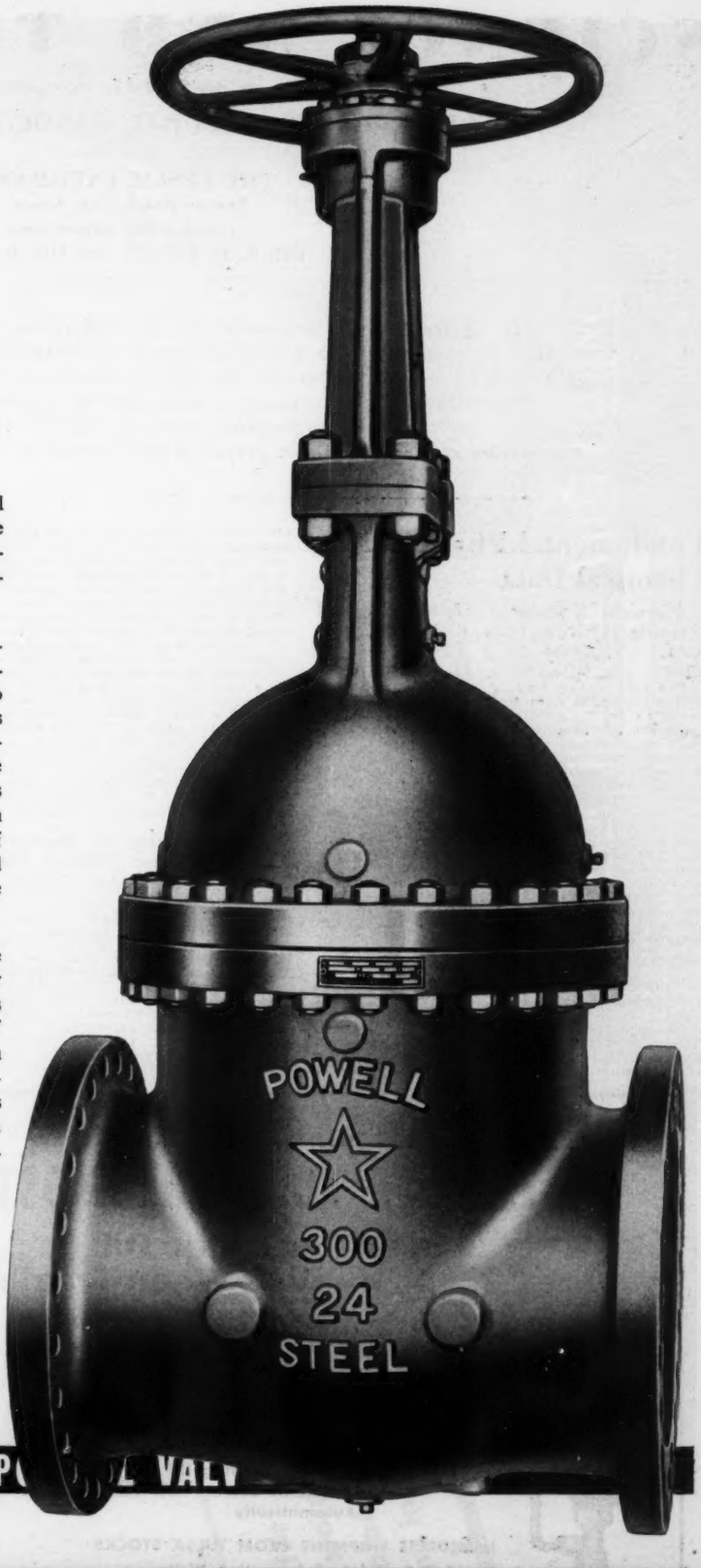

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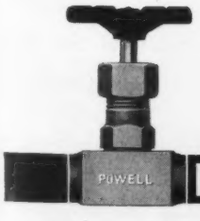

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The abstracts here presented are selected from the current literature of science and technology to afford reference to fundamental information not easily available to all readers. Abstracts of articles appearing in readily obtainable trade journals are not included.

Photostat copies of original articles will be supplied at cost by the Leslie Laboratories. Complete or limited bibliographies covering special topics by title, by abstracts, or in complete manuscript, will also be prepared and furnished at reasonable cost by the Laboratories.

Fundamental Physical and Chemical Data

Physical Constants of the Normal Paraffin Hydrocarbons, R. M. DEANESLY AND L. T. CARLETON, *J. Phys. Chem.* **45** (1941) pp. 1104-23.

Freezing point, boiling point, density, and refractive index data for the normal paraffins from C_5 to C_{18} have been carefully selected from the literature, and in the case of *n*-dedecane and hexadecane determined from compounds produced in the laboratory. Densities and refractive indices were correlated in order to form smooth series with respect to increment of molecular volume and to constancy of increment of molecular refraction. A reference hydrocarbon of high molecular weight was needed. Hexadecane was chosen because it has the highest molecular weight of any of the normal paraffins that are liquid at 20° C., and also, it is easy to purify. Best values for the refractive indices of the C_5 to C_{12} paraffins and hexadecane were selected from the literature. Values of molecular refractions could be calculated from the smoothed molecular volumes and the $n\frac{20}{D}$ values. The increment of molecular refraction was 4.6404. Above C_5 the smoothed value of *n* and *d* were in exact linear relation at 20° C., and in accordance with the equation: $n = 0.52167d + 1.03104$. The values of *n* calculated from this equation agreed with the smoothed values derived from the molecular refraction to 0.00004 or less for the entire series from C_6 to C_{18}. In studying the changes in *n* and *d* with temperature, the the best values of the rates of change of *n* and *d* with temperature were selected from the literature and plotted against the corresponding values of *n* and *d*. The density coefficient is well established, and a smooth curve could be located by inspection. The data for rate of change of *n* with temperature are not so numerous nor reliable. The curve was smoothed with the aid of a derivation from: $n = Ad + B$, in which A and B are functions of temperature alone. Since it was assumed that if *n* was a linear function of *d* at 20° C. it was also such at 25°. An equation was derived, and from this, and the rate of change of density with temperature the rate of change of refractive index with temperature for all the normal paraffins was established from C_6 up. The constants accepted for the normal paraffins are summarized in a table.

Determination of Beattie-Bridgeman Constants from Critical Data, F. W. BROWN, *Ind. & Eng. Chem.* **33** (1941) pp. 1536-39.

Maron and Turnbull developed a method for determining the constants of the Beattie-Bridgeman equation of state for any gas from the critical data for that gas and from the critical data and Beattie-Bridgeman constants of a reference gas. The method is based on the assumption that most gases have the same activity coefficient at the same reduced temperature and pressure. From their derived expressions for the activity coefficient in terms of Beattie-Bridgeman constants and critical data, they are able to derive expressions for the ratio of the constants of any two gases in terms of the ratio of critical pressures and temperatures. The purpose of the author's paper is to point out that the relations obtained by Maron and Turnbull are an expression of the law of corresponding states in terms of intermolecular forces and to point out the theoretical reasons for excepting deviations. A simple method is developed for deriving the equations of Maron and Turnbull for the determination of the constants in the Beattie-Bridgeman equation in terms of the constants of a reference gas and the critical temperature and pressure. The theoretical basis for their procedure is discussed, and the constants for hydrogen are recalculated on the basis of the Lennard-Jones model of intermolecular forces.

The Heat Capacity, Entropy, and Heats of Transition, Fusion, and Vaporization of Dimethylacetylene. Free Rotation in the Dimethylacetylene Molecule, D. M. YOST, D. W. OSBORNE, AND C. S. GARNER, *Jour. Amer. Chem. Soc.* **63** (1941) pp. 3492-96.

As a result of work by Kemp and Pitzer, the existence of a barrier restricting the rotation of the methyl groups in ethane and similar molecules is now generally accepted. One purpose of the research described in this paper was to determine the extent of any barrier restricting the rotation of the methyl groups in dimethylacetylene. It was found that the methyl groups in dimethylacetylene were subject to little, if any, restriction, in their rotation. The heat capacity of dimethylacetylene was measured from 14° K. to room temperature. There is an anomaly in the heat capacity near 154° K. The melting point of dimethylacetylene is 240.93 ± 0.05° K. The heat of fusion is 2207 ± 2 cal./mole, and the heat of vaporization is 6440 ± 6 cal./mole at 291° K. and 536 mm. The entropy of the ideal gas from the calorimetric data is 67.48 ± 0.20 cal./deg./mole and 67.93 cal./deg./mole at 1 atmosphere, 291° K, and 298.16° K, respectively. That of the liquid at 298.16° K. is 46.63 ± 0.1 cal./deg./mole. Comparison of the statistical and calorimetric entropies indicates that the barrier restricting rotation of the methyl groups is not more than 500 cal./mole as compared to approximately 3000 cal./mole in the molecule ethane.

Heats of Isomerization of the Five Hexanes, E. J. R. PROSEN AND F. D. ROSSINI, *J. Res. Natl. Bur. Stand.* **27** (1941) pp. 289-310. (Res. Paper No. 1420.)

A precision bomb calorimeter was used to determine the ratios of the heats of combustion of the five hexanes. From these measurements the heats of isomerization ΔH for the reaction $n\text{-}C_6H_{14} = i\text{-}C_6H_{14}$ were calculated. The following values were obtained for the liquid state at 25° C. in kg./cal./mole: n-hexane 0, 2-methylpentane -1.30 ± 0.21, 3-methylpentane -0.76 ± 0.19, 2, 3-dimethylbutane -1.96 ± 0.20, 2, 2-dimethylbutane -3.49 ± 0.18. Values for the heats of isomerization for the hydrocarbons in the gaseous state at 0°, 298°, 600° and 1000° K were calculated.

Heats of Dissociation of Some Hexaarylethanes, R. PRECKEL AND P. W. SELWOOD, *Jour. Amer. Chem. Soc.* **63** (1941) pp. 3397-3403.

The purpose of the investigation was to measure the equilibrium constants, the heats,

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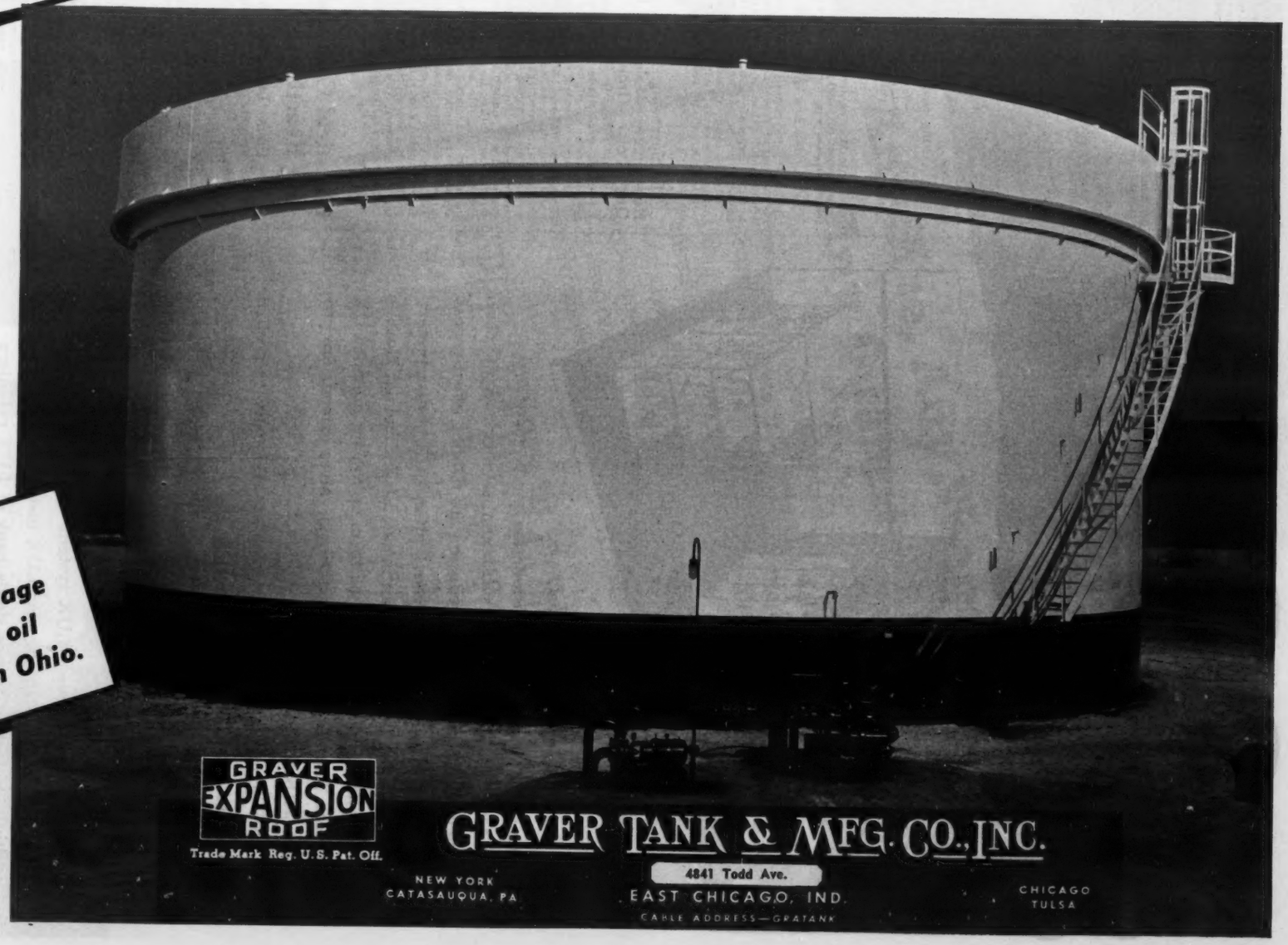

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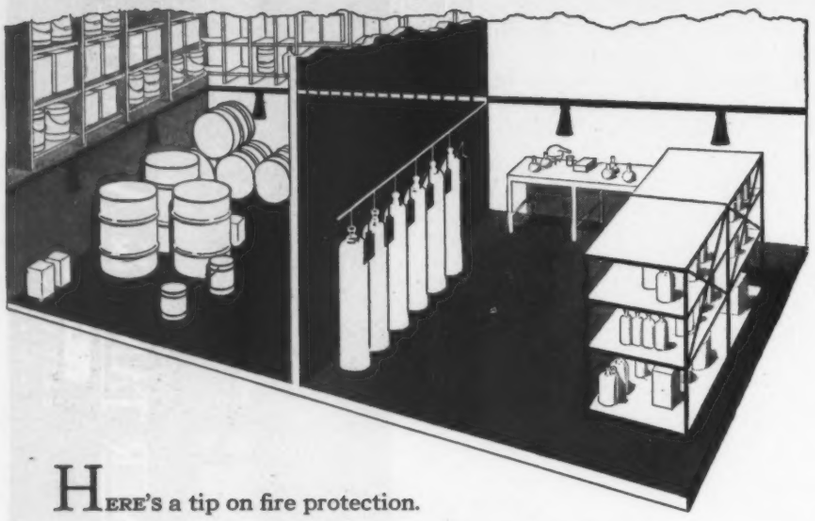

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and the entropies of dissociation of several hexaarylethanes, with the primary object of testing experimentally some of the current theories of free radical stability. Magnetic measurements at several temperatures and concentrations were made on toluene solutions of the following hexaarylethanes: hexaphenylethane, di - o - tolyltetraphenylethane, di - a - naphthyltetraphenylethane, and tetra-o-tolyldiphenylethane. The results show that the entropy change of dissociation is not independent of substituent, and they support the "steric" rather than the "resonance" theory of free radical stability. They also show that ebullioscopic measurements may be useless for free radical studies, and that the color of the solution is in no sense an accurate measure of free radical concentration.

Viscosity Nomographs for Organic Liquids, D. S. DAVIS, *Ind. & Eng. Chem.* **33** (1941) pp. 1537-39.

Souders showed that for a wide range of organic liquids the logarithm of the logarithm of the viscosity in millipoises is linear with the density in grams per cubic centimeter according to the expression

$$\log (\log n) = md - 2.9$$

where m is a constant characteristic of each liquid. The calculated the viscosity-density constant, m, by the equation

$$m = I/M$$

in which M = molecular weight and I = viscosity-constitutional constant. The two equation can be combined to give:

$$\log (\log N) = I\ d/M - 2.9$$

The viscosity-constitutional constant, I, can be evaluated from the summation of general atomic and structural constants as given in a table presented in the author's article. A nomograph is presented for solving equation 3 quickly and accurately. Two other nomographs are presented for more limited ranges, but which can be used to permit closer estimation of viscosity.

The Spreading of Oils on Water. II. Non-Ionized Molecules Having Only One Polar Group, W. A. ZISMAN, *J. Chem. Phys.* **9** (1941) pp. 729-41.

Studies were made of the spreading on water of drops of oil containing small amounts of alcohols, esters, ketones, phenols, non-ionized acids and non-ionized amines. Such polar molecules do not cause spreading unless the molal concentration exceeds a critical value which varies with the nature of the polar group, the chain length, the possible geometrical configurations of the molecule, and the solubility in oil. The cause of spreading is a reversible adsorption at the oil-water interface associated with the osmotic pressure of the polar molecules dissolved in the oil. Certain new spreading phenomena caused by formation of colloidal suspensions, and the crystalline precipitate of the polar compounds are described. Use is made of the latter to measure the solubility in oils of the various straight-chain saturated acids and alcohols.

Chemical Compositions And Reactions

Reactions Involved in the Liquid-Phase Alkylation of Isoparaffins with Olefins, S. H. MCALLISTER, J. ANDERSON, S. A. BALLARD, AND W. E. ROSS, *J. Org. Chem.* **6** (1941) pp. 647-68.

In order to study the reaction mechanism of the sulfuric acid alkylation process as applied in the production of octane, 2 series of experiments in both batch and continuous operations were conducted. The reaction products were separated by fractional distillation and identified by refractive index and specific gravity. The results are given in several curves and tables, and indicate the following types of reactions: hydrogenation occurs to some extent in most alkylations; depolymerization occurs in some instances; ring isomerization as shown by the formation of methylcyclopentane in the alkylation of trimethylmethane with cyclohexene; olefin isomerization occurs in some cases. Cleavage of the carbon-carbon bond happens to some degree, followed by recombinations of the fragments with olefins. Several paraffins and olefins were used in the study.

Kinetics of the Thermal Decomposition of Straight Chain Paraffins, R. E. BURK, L. LASKOWSKI, AND H. P. LANKELMA, *Jour. Amer. Chem. Soc.* **63** (1941) pp. 3248-50.

Several conflicting theories have been proposed for the mechanism of the thermal decomposition of straight chain paraffins. One of these assumes that free radicals are formed in the initial step. One of the authors

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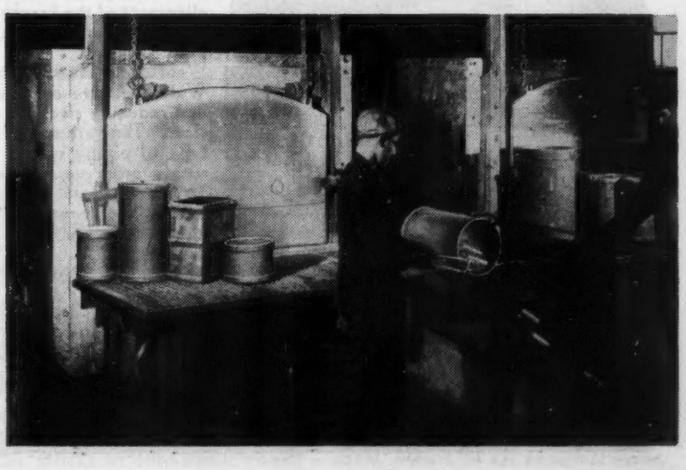

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has developed an alternate theory based on the initial decomposition to an olefin and a paraffin rather than free radicals. The constancy of the activation energy for the thermal decomposition of a straight chain paraffin calculated from experimentally determined velocity constants using the equation derived from the Burk mechanism which assumes equally probable scission of C-C bonds to form an olefin and a new hydrocarbon, corroborates the assumptions of the Burk mechanism. The rate of decomposition for a simplified chain mechanism has been shown to be proportional to a power of n at least as great as $(n-2)^2-(n-1)^{1/2}$ where n is the number of carbon atoms in the decomposing hydrocarbon.

Fluorinated Derivatives of Propane. IV., A. L. HENNE AND F. W. HAECKL, *Jour. Amer. Chem. Soc.* **63** (1941) pp. 3476-78.

The authors describe the synthesis of two tetrafluorotetrachloropropanes. These compounds are $CCl_2FCClFCClF_2$ and $CCl_3CClFCF_3$.

Isomerization Equilibrium Among the Branched Chain Pentenes, R. H. EWELL AND P. E. HARDY, *Jour. Amer. Chem. Soc.* **63** (1941) pp. 3460-65.

Various pure pentene isomers were isomerized in the vapor phase over solid catalysts in a sealed apparatus held at desired temperatures. The resulting mixtures were then analyzed by distilling in an efficient fractionating column. In the column used it was found possible to make a fair separation between 2-pentene and 2-methyl-2-butene (the boiling point difference 1.6° to 2.8° C.), but impossible to make a separation between two pentenes boiling only 0.9° C. apart. The column used had approximately 80 theoretical plates. The best catalyst was found to be activated alumina, as this produced the greatest change at the lowest temperature. It was therefore used in experiments to effect equilibrium. Equilibrium was obtained at four temperatures, 251°, 300°, 358° and 400° C. At the three highest temperatures it took 12 hours to obtain equilibrium. At the lowest temperature, however, it required 24 hours. The entropies of the branched chain pentenes were calculated by a method based on the assumption that the entropy of 3-methyl-1-butene is 81.7 e.u. Experiments were made on the isomerization of the straight chain pentenes. Most of the catalysts produced approximately the same amount of isomerization of 2-pentene, namely, 10-15%, and the single experiment on 1-pentene resulted in the same mixture as did the experiments on 2-pentene.

Olefins and Diolefins from Allylic Chlorides, A. L. HENNE, H. CHANAN, AND A. TURK, *Jour. Amer. Chem. Soc.* **63** (1941) pp. 3474-76.

The work reported is part of the American Petroleum Institute Pure Hydrocarbon Program, operated as Project No. 31 of The Ohio State University Research Foundation. Irrespective of cis-trans isomerism, which was not considered, most allylic chlorides exist in two forms. Crotyl chloride, for example, is a mixture of a primary chloride and a secondary chloride. This permits the synthesis of two olefins by the reaction with a Grignard derivative, three diolefins by condensation on magnesium, or ten diolefins by condensation of two different allylic halides. Several allylic chlorides were prepared. These were condensed with Grignard reagents or with themselves to synthesize diolefins. The products obtained are described and listed in tables. The proportions of the different products in the various reactions were ascertained. The configurations of the olefins and diolefins were established.

The Use of Amalgamated Aluminum as a Catalyst in the Friedel and Crafts Reaction, L. I. DIUGUID, *Jour. Amer. Chem. Soc.* **63** (1941) pp. 3527-29.

It has been shown by the author that a series of alkylbenzenes can be prepared via the Friedel and Crafts procedure using amalgamated aluminum catalyst. The alkylbenzenes can be prepared in this manner with less rearrangement, formation of tars, disproportionation and dimerization than by the use of aluminum chloride in the usual Friedel and Crafts alkylation reaction. Among the compounds prepared were ethylbenzene, isopropylbenzene, s-butylbenzene, t-butylbenzene, and s-butyl-a-naphthalene. Data are given on the yield and characteristics of the products obtained.

High-Temperature Alkylation of Aromatic Hydrocarbons, A. N. SACHANEN AND A. A. O'KELLY, *Ind. & Eng. Chem.* **33** (1941) pp. 1540-44.

The authors note that the low-temperature alkylation of aromatic and paraffinic hydrocarbons with olefins in the presence of acids or metal chlorides has been investigated

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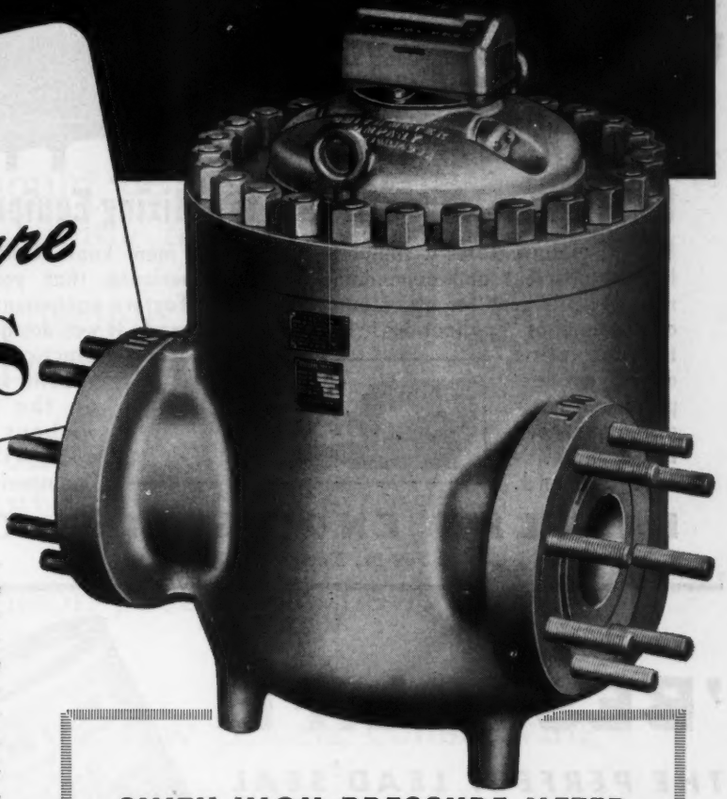

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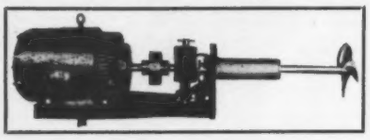

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by several writers, but that little has been done on high-temperature alkylation. The subject of high-temperature alkylation is briefly reviewed. Thermodynamic data are presented on alkylation reactions, and it is seen that the thermodynamic probability of alkylation of aromatics is greater than that of polymerization or of alkylation of paraffins. The indication is that alkylation of the aromatics with olefins may occur at temperatures as high as 930-1110° F. and under atmospheric or slightly elevated pressures. Batch and continuous procedures for the alkylation of the aromatic hydrocarbons benzene and toluene are described. These were alkylated with olefins at temperatures of 800° F. and above. The reaction was effected under atmospheric pressure and in the absence of catalysts, but high pressures and such catalysts as activated clay improved the yields of alkyl aromatics. Toluene is more easily alkylated than benzene at these temperatures. On the other hand propylene and butylene are stronger alkylating agents than amylene. Under high temperatures the alkyl aromatics produced were partially cracked, forming alkyl aromatics of a lower molecular weight. As a result, alkyl aromatics formed were composed of an entire series of aromatics beginning with toluene and increasing in molecular weight. The alkyl aromatics produced contained 90 percent or more of purely aromatic hydrocarbons. The experimental data are presented in tabular and graphical form.

Identification of Organic Compounds. IV. Chlorosulfonic Acid as a Reagent for Identification of Alkylbenzenes, E. H. HUNTRESS AND J. S. AUTENRIETH, *Jour. Amer. Chem. Soc.* **63** (1941) pp. 3446-48.

The use of chlorosulfonic acid as a tool for the characterization of organic compounds has now been extended to a group of alkylbenzenes. The principle employed involves two stages of reaction, including direct introduction of one sulfonyl chloride group into the aromatic nucleus by direct treatment with excess chlorosulfonic acid in chloroform followed by conversion of the resultant sulfonyl chlorides into the corresponding sulfonamides. Data are given in the article on the identification of 37 aromatic hydrocarbons, most of which are alkylated benzenes.

The Synthesis of Condensed Ring Compounds. VII. The Successful Use of Ethylene in the Diels-Alder Reaction, L. M. JOSHEL AND L. W. BUTZ, *Jour. Amer. Chem. Soc.* **63** (1941) pp. 3350-51.

It has become increasingly evident during the last few years that the ability of the olefinic linkage to undergo 1, 4-addition to conjugated dienes is more general than was originally supposed. Under suitable temperatures and pressures, ethylene reacts with 1,3-dienes in the usual Diels-Alder manner. In this way cyclohexene, 1,2-dimethylcyclohexene, and bicyclo (2, 2, 1)-2-heptene have been synthesized from 1,3-butadiene, 2,3-dimethyl-1,3-butadiene and cyclopentadiene, respectively.

The Photolysis of Ketene in the Presence of Hydrogen and Methane, C. ROSENBLUM, *Jour. Amer. Chem. Soc.* **63** (1941) pp. 3322-29.

When gaseous ketene is irradiated with ultraviolet light the pressure increases and the gas phase is found to contain ethylene and carbon monoxide. The extent of the photodecomposition of ketene by ultraviolet light at about 45° C. appears to be independent of the nature of subsequent reactions, thus supporting the supposition that methylene radicals are produced as a result of light absorption. In the presence of hydrogen the gaseous hydrocarbon is to a considerable degree saturated. Simultaneously a saturated condensed polymeric product is formed. The formation of saturates has been attributed to a reaction between hydrogen and methylenes to yield methyl radicals and hydrogen atoms, which is considered to proceed simultaneously with the recombination of methylenes to yield ethylene. Saturates are formed also in the presence of methane, at the expense of the latter just as in the case of hydrogen. This is attributed to a reaction between methylene radicals and methane to form methyl radicals. The principal effect of ethylene is to increase the amount of condensed polymer.

The Polymerization of Olefins Induced by Free Radicals, C. J. DANBY AND C. N. HINSHELWOOD, *Proc. Roy. Soc.* (London) **179A** (1941) pp. 169-93.

Mixtures of aldehyde or ketone and olefin were exposed to ultraviolet light, and when photolysis occurred, the olefin was polymerized. The rate of photolysis of the simple aldehydes is in general reduced by ethylene,

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propylene or isobutylene. The light source was an Hanovia mercury lamp which was focused on the reaction vessel by a spherical silica flask of water. From the experimental observations a mechanism is proposed for the induced polymerization. The rate of photolysis of aldehyde is, in general, reduced by olefins. As the olefins do not absorb light of the wave length used, this inhibition is caused by removal by reaction with olefin of a chain-carrying radical from the aldehyde photolysis, and polymerization occurs by the successive addition of olefin molecules to the new radical formed. The reaction apparently involves a chain transfer process, or the breaking down by regeneration of a methyl radical that begins a new polymerization chain. The polymer fails to incorporate more than about three molecules of ethylene. This is probably caused by decomposition rather than a failure of further reaction with ethylene. The polymerization rate diminishes in the series ethylene, propylene, isobutylene. Oxygen had little effect on the reaction, and it was concluded that its effect could be attributed entirely to the oxidation of part of the acetaldehyde.

Manufacture: Processes And Plant

Mean Temperature Difference in Multipass Exchangers, K. A. GARDNER, *Ind. & Eng. Chem.* **33** (1941) pp. 1495-1500.

Correction factors for the mean temperature difference in multipass heat exchangers may be derived on the basis of either of two assumptions: (1) the shell fluid is completely mixed over any cross section; or (2) the shell fluid does not mix at all. The author considers a case in which the baffling system of the exchanger is designed to discourage mixing. Correction factors derived on this basis, when compared with those of Nagle, who proceeded on the basis of complete mixing, show the limits within which the true correction factors lie, and provide a quantitative indication of the relative merits of the two types of flow. Mean temperature difference correction factors are presented for heat exchangers where the shell fluid is not mixed. These factors are shown to be higher than those for exchangers in which the shell fluid is completely mixed. Conditions are discussed under which it may be desirable to design a heat exchanger deliberately to prevent mixing of the shell fluid. Correction factors are presented in chart form for different types of exchangers, and for mixed and unmixed shell fluid.

The Cost of Process Equipment and Accessories, H. BLISS, *Chem. & Met. Engr.* **48** (1941) pp. 88-98.

The paper presented first appeared in the October 25 issue of the Transactions of the American Institute of Chemical Engineers, and is reprinted largely without change in Chemical and Metallurgical Engineering. A review of the previous paper appeared in these abstracts. The purpose of the author is to furnish data from which preliminary estimates can be made for use in cost-finding studies.

Corrosion Coupons and Pipe-Life Predictions, W. R. SCHNEIDER, *Gas Age 88* **No. 7** (1941) p. 21.

The Pacific Gas and Electric Company has had 10 years of experience in the use of corrosion coupons or test plates buried near a pipe line for the purpose of indicating the rate of corrosion resulting from soil action, stray currents, and the like. The plates are buried in pairs at the depth of the pipe. The size of the plate is 3 x 6 x 5/16 inch. The material is hot-rolled steel cut from bars. The pipes are cleaned by sand blasting, drilled, numbered and weighed. One plate is connected to the pipe, the other is not. The test pieces are removed from the ground at the end of a year and replaced by new pieces. The pipes are cleaned and examined, particularly for depth of pit. The method of predicting the depth of the pit at the end of 2 years is presented. It is stated that contradictory estimates of the life of a pipe may result from the indications of coupons of only a single year. The prediction might differ by as much as 2.7 and 12 years.

Prediction of Octane Numbers and Lead Susceptibilities of Gasoline Blends, D. EASTMAN, *Ind. & Eng. Chem.* **33** (1941) pp. 1555-60.

Commercial gasolines are generally prepared by blending a variety of component gasolines or blending stocks, produced by different refining procedures. Tetraethyllead is finally added in sufficient quantity to obtain the desired octane number in the finished gasoline. Data on pure hydrocarbons and experience with commercial gasolines have shown that the octane values of blends of saturated hydrocarbon types, such as paraffins and naphthenes, are related arithmetically to the octane numbers of the components and to the relative proportions in which they are blended. If, however, these materials are blended with unsaturated fractions containing olefinic or aromatic hydrocarbons, substantial deviations from an arithmetic relationship are commonly found. Methods for the prediction of the octane numbers and lead response characteristics of gasoline blends are presented. Octane numbers are predicted by means of a blending coefficient which has been correlated with the difference in octane sensitivity between the stocks blended. A modification of the Hebl, Rendel, and Garton chart is presented for the evaluation of lead response, and correlations for the prediction of this factor from sulfur content and octane sensitivity are given. Methods for the prediction of the lead response of blends are described. It is pointed out that all the correlations are empirical and should be verified before being applied to unusual stocks.

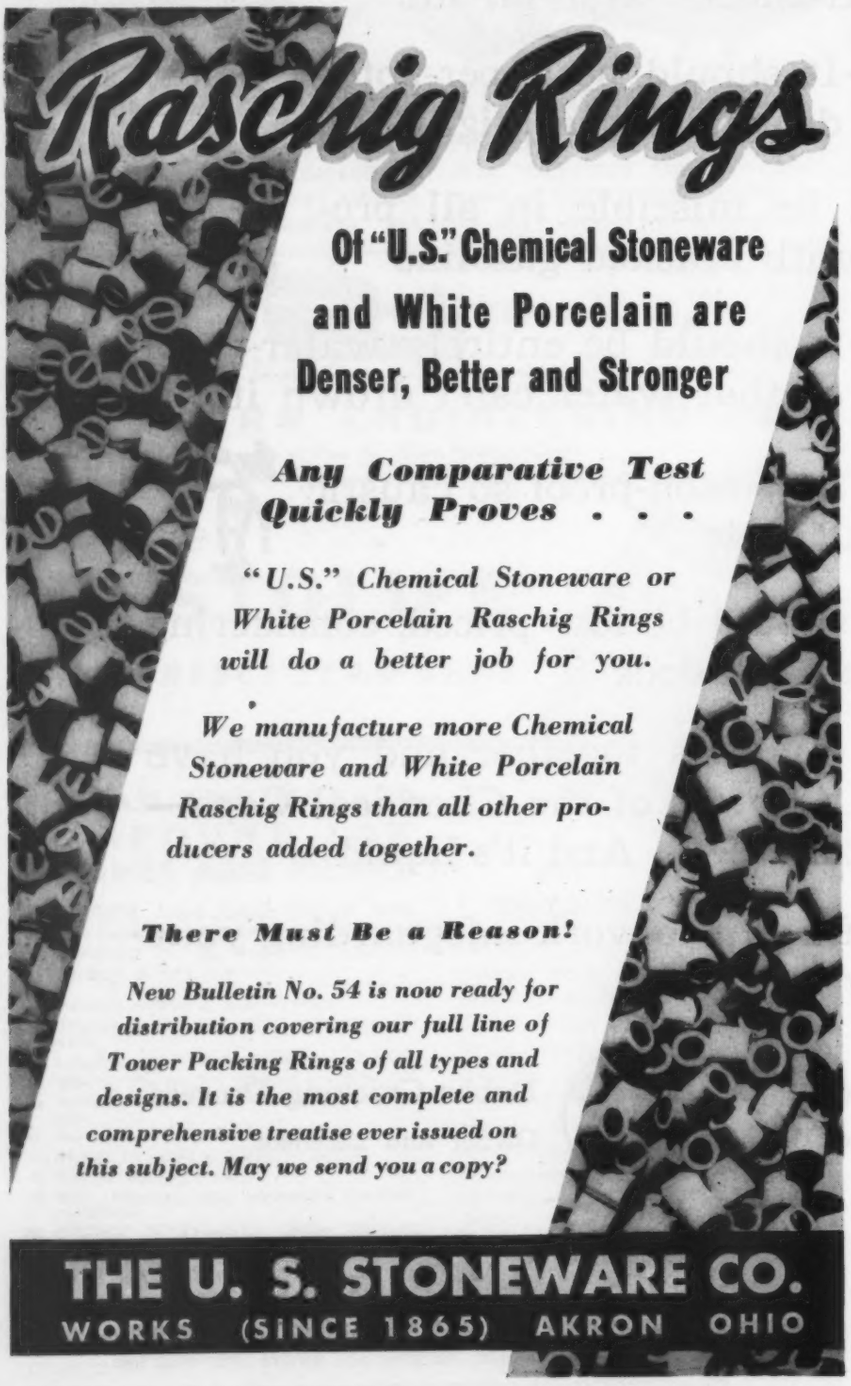
Products: Properties And Unitization

Cooperative Fuel Research Motor-Gasoline Survey, Winter 1940-41, E. C. LANE, *U. S. Bur. Mines, Rept. Investigations 3576* (1941) 29 pages.

Analytical data are presented in the report for 2020 samples. Octane number was higher than in 1939-40, 1.7 units for regular- and premium-grade, 1.4 units for third-grade. Average vapor pressure of gasolines was higher. Average temperatures in distillations were slightly lower.

Comparative Performance of Alcohol-Gasoline Blends in a Gasoline Engine, A. R. ROGOWSKI AND C. F. TAYLOR, *J. Aeronaut. Sci.* **8** (1941) pp. 384-92.

The object of the investigation was to compare the performance of ethyl-alcohol-gasoline blends with that of gasoline alone, as fuel for internal-combustion engines. Tests were made using commercial 70 octane number gasoline, and blends of this gasoline with 10, 25 and 50% of anhydrous ethanol. The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blends were made by volume. Tests were also made with 95% ethanol, and with leaded gasoline. The conclusion reached was that alcohol blends are uneconomical compared to gasoline under any engine operating condition, unless the price of the blend is at least as low as that of gasoline.

New British Specification for Anti-Freezing Oil, *Petr. Times* **45** (1941) p. 517.

The British Ministry of Aircraft Production recently issued Material Specification D.T.D. 44D (superseding 44C) for Anti-Freezing Oil, Type 44D. This oil shall be a pure highly refined mineral oil compounded with 0.05 to 0.1 percent of stearic acid or other approved substance for improvement of lubricating power. It shall be clear and light in color, and free from dirt, suspended matter, water, and other visible impurities. Kinematic viscosity shall not be more than 120 centistokes at 32° F. nor less than 13 centistokes at 100° F. Flash point shall not be lower than 143° C. The aniline point shall not be lower than 85° C. when determined by a method described in the Specification. Anti-freeze oil shall also be free from mineral acid, and the total organic acid shall not correspond to more than 0.3 mg. of caustic potash per gram of oil. Saponification value shall not correspond to more than 1.0 mg. of caustic potash per gram of oil. The ash content shall not exceed 0.01 percent, the oil shall flow at a rate of not less than 1 cm. per minute at —45° C. when determined by a method described in the specification.

Methods of Light Hydrocarbon Analysis, J. J. SAVELLI, W. D. SEYFRIED, AND B. M. FILBERT, *Ind. & Eng. Chem., Anal. Ed.* **13** (1941) pp. 968-79.

In recent years the low molecular weight hydrocarbons have become increasingly important as raw materials, and there is every indication that this trend will continue. The investigation reported included studies of several of the more widely accepted methods of analysis of mixtures of light hydrocarbons from methane through isopentane. When results indicated it to be desirable, the methods were modified. In some instances the methods were subjected to a theoretical analysis to determine the maximum accuracy to be expected. Consideration was given to accuracy, reproducibility, simplicity, speed, and economy of materials. Synthetically prepared mixtures were used in the studies. Consideration was given to methods of sampling and handling the mixtures prior to analysis. Methods studied included the automatically controlled Podbielniak (Model L) column, the Ward method utilizing low-pressure fractional distillation and condensation, a dew-pressure method for n-butane-isobutane mixtures, the determination of olefins by absorption in various reagents including sulfuric acid, and bromine solutions, and catalytic hydrogenation, and the determination of isobutene by absorption in reagents and by its reaction with anhydrous hydrogen chloride. The data obtained in the course of the work are presented in 17 tables, and the procedures, and the results secured by their use, are discussed in some detail. A bibliography of 16 references is included.

Instrumental Methods of Chemical Analysis, R. H. MULLER, *Ind. & Eng. Chem.,* Anal. Ed. **13** (1941) pp. 667-754.

Remarkable advances have been made in the application of instruments to the problems confronting the chemist. The Editorial Staff of the Analytical Edition of Industrial and Engineering Chemistry has arranged for a series of expert reviews, several of which are in preparation. This series is prefaced by the current article, which is a preliminary survey or classification designed to illustrate the contemporary status of the field, to indicate the wide variety of techniques, and to dispel the idea the progress is largely confined to a certain specialty or method. When the survey of modern analytical chemistry requires the description of instruments ranging from hydrometers to cyclotrons and it can be shown that these devices are all eminently practical and paying their way, it may be wondered how the modern analyst is to be appraised. He must become familiar with a bewildering array of techniques and at least moderately acquainted with the dialect of the physicist and engineer. The article of some 83 pages presents data on a wide variety of instruments, includes 191 figures, and is concluded with a bibliography of 313 references. Following the article the Analytical Edition presents a directory of instruments and the latest apparatus.

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The purpose of this excess-flow-check valve is to prevent excessive discharge of fuel to atmosphere in the event of pipe, tubing or connection failure.

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Keasby & Mattison Company, Ambler, Pennsylvania, has perfected a building material made entirely of asbestos-cement products. The product is the result of an effort to find material to replace steel.

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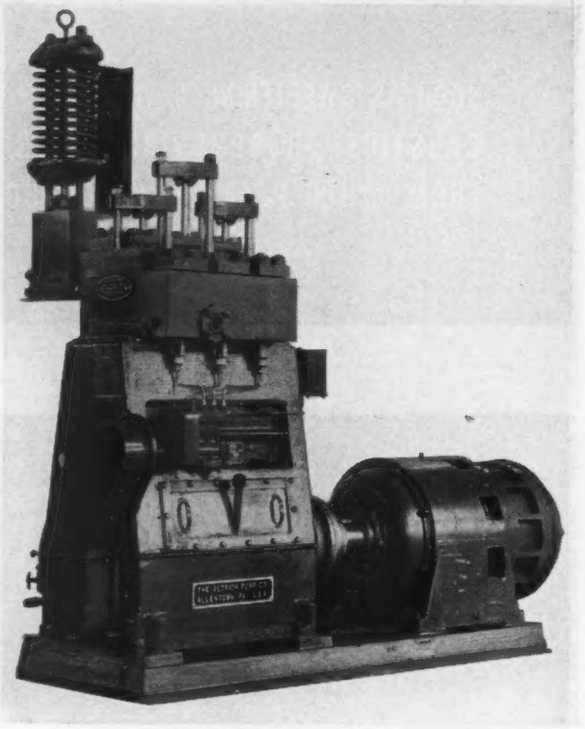

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General Electric Company, Schenectady, New York, has announced the addition of two new forms to its line of CR9441-C2 rotating-type limit switches. One form is for Class 1, Group D hazardous gas locations and the other is for applications requiring water-tighteners. The new switches are both housed in heavy, flanged, cast-iron enclosures.

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Fischer & Porter Company, 20 County Line Road, Hatboro, Pennsylvania, is offering a line of automatic flow controllers for viscous and corrosive fluids.

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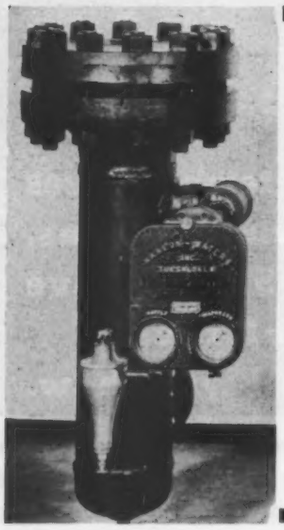

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Allis-Chalmers Manufacturing Company, Milwaukee, has announced a protection "safety circle," for its new LO-Maintenance motors. The protection is a wide, solid rib, integrally cast as part of the frame, which forms an unbroken circle of protection around the stator.

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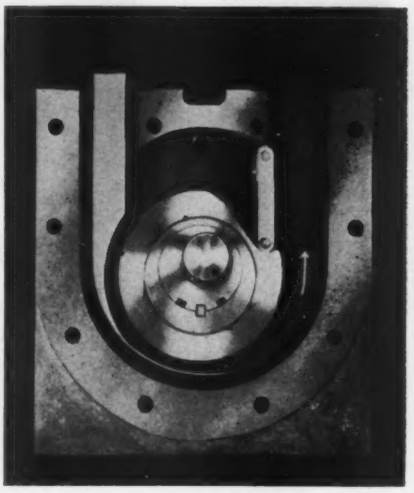
Allis-Chalmers Motor

Squeegee Pump

DOWNINGTON MANUFACTURING COMPANY

Downington Manufacturing Company, Huber Pump Division, Dowington, Pennsylvania, is offering a squeege type pump, which moves liquids and gases through pulsations of a rubber tube. Operation of the pump is by an off-center rotor which through an adjustable eccentric drives a rocking compressor ring, which in turn compresses and releases a rubber tube to cause the effect of breathing into and from the tube.



Downington Squeegee Pump

The liquid or gas is inclosed in the tube from the time it enters the pump until it leaves. The tube may be made of pure gum rubber or from acid-and-oil-resisting synthetic materials. The tubes may be lined with synthetic materials for corrosion resistance. Solids may be handled as well as hot or cold liquids and gases.

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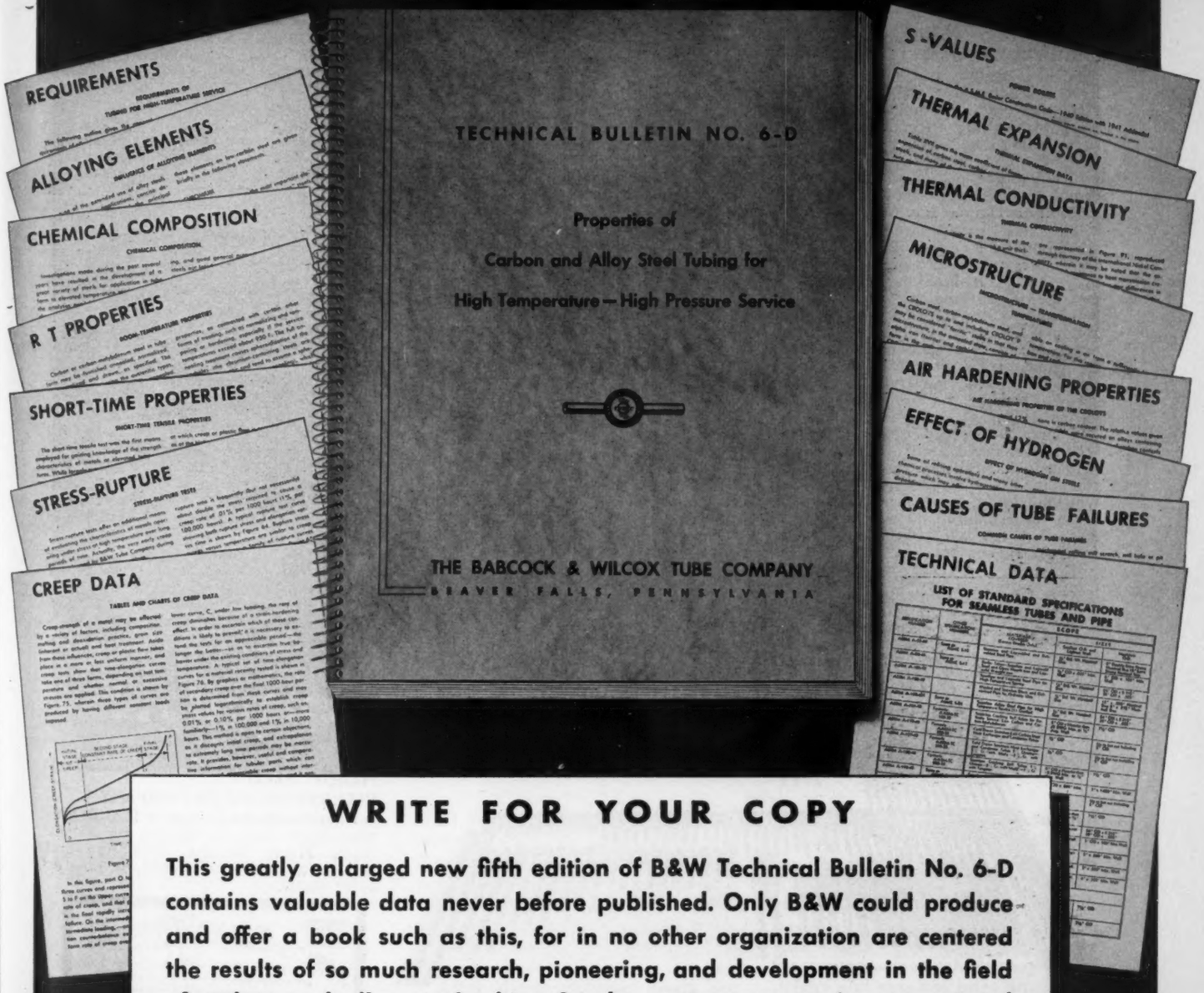

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This greatly enlarged new fifth edition of B&W Technical Bulletin No. 6-D contains valuable data never before published. Only B&W could produce and offer a book such as this, for in no other organization are centered the results of so much research, pioneering, and development in the field of carbon and alloy steel tubing for the most severe service encountered in oil refining, steam generation, and kindred applications.

You will find this 157-page volume invaluable in choosing tubing of greatest utility and economy wherever temperature, pressure, and corrosion are severe. Your copy of this new book will be mailed to you promptly upon request on your company letterhead.

TA-1195

BABCOCK & WILCOX TUBES

HOT FINISHED COLD DRAWN ALLOY STEELS CARBON STEELS

THE BABCOCK & WILCOX TUBE COMPANY, BEAVER FALLS, PA.

vances the liquid or gas while expansion back to normal diameter produces a high vacuum for intake.

The pumps are made in both single- and double-stage. There are six standard sizes in the single-stage from a half gallon to 50 gallons per minute. All sizes can be supplied with base plates to take several pumps of the same size for direct connection with one motor.

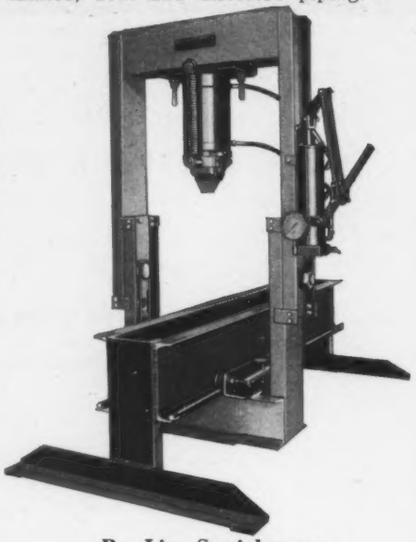
Camouflage Paint
SHERWIN-WILLIAMS COMPANY

Sherwin-Williams Company, Cleveland, has announced a list of paints for concealing military and civilian objectives by making them blend in with surrounding colors of earth and foliage. Officials of the company point out that no camouflage painting should be undertaken until authorized by the local director of camouflage.

The new paints are designed for spreading over roofs, buildings, streets and other structures which disclose the presence of a bombing objective or which serve as landmarks from the air. They dry without gloss or reflections and permit streets to be "painted out" or non-existent streets to be "painted-in," and make conspicuous objects merge into the natural background. They adhere to practically any type of surface from glass to asphalt roofing, and may be spread over blacked-out windows, roads, sidewalks, tanks, smokestacks, railway ties, etc. One of their most immediate uses, the Sherwin-Williams color experts believe, will be in the repainting of gasoline and oil storage tanks and tank farms to confuse enemy bombers.

Pipe Straightener
BEE-LINE COMPANY

Bee-Line Company, Davenport, Iowa, has devised a hydraulic press for straightening pipe. It will handle pipe as large as 14 inches and has pressure of 125 tons. Special tools are provided for reclamation and conservation of kinked, bent and distorted piping.



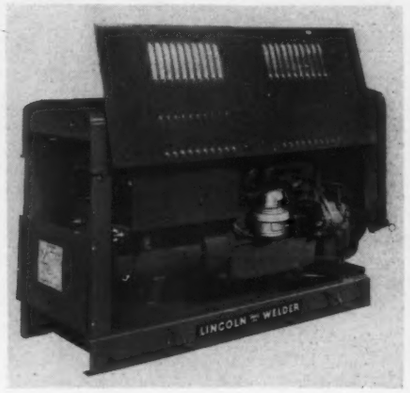
Bee-Line Straightener.

The press is mounted on a movable roller-bearing carriage which permits application of pressure at any point in the bed. The jack carriage can be raised or lowered 16 inches with a minimum space between the ram and the bed of 2 inches and a maximum space of 28 inches. The ram travel is 10 inches. The jack features three speeds—high, medium and low. Overall dimensions of the complete press are: Length 8 feet, width 4 feet 8 inches, weight 4000 pounds.

Engine-Driven Welder
THE LINCOLN ELECTRIC COMPANY

The Lincoln Electric Company, Cleveland, Ohio, has announced an engine-driven arc welder which embodies a new system of engine-speed control for maximum fuel economy and minimum engine wear.

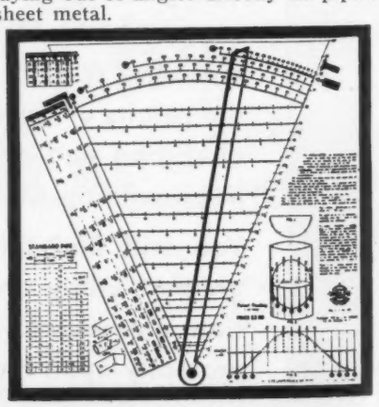
With a current range of 40 to 250 amperes, the machine can be used for the welding of light-gauge metal, for the repair of cast-iron parts such as



engine blocks, for fabrication of machine parts and structures of many kinds, and for hard facing of worn parts. Of direct-current type, it can weld effectively practically all metals and alloys with bare or shielded arc type electrodes or with the carbon arc where desirable. Its compactness and light weight make it readily portable and hence suitable for work in remote locations as well as those applications which are readily accessible.

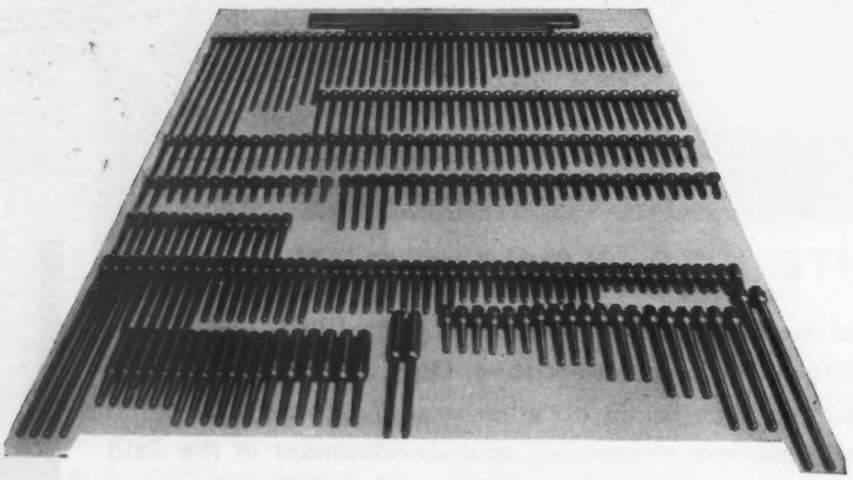
Angle Meter
INTERSTATE SALES COMPANY

Interstate Sales Company 1123 Broadway, New York, is offering the Wolfe Angle Meter, for the calculation and laying out of angles directly on pipe or sheet metal.



Wolfe Angle Meter

Using a method of measuring in both directions from a center line, it requires only four measurements to mark a pipe or stretch out in 16 different points on the circumference. All measurements are

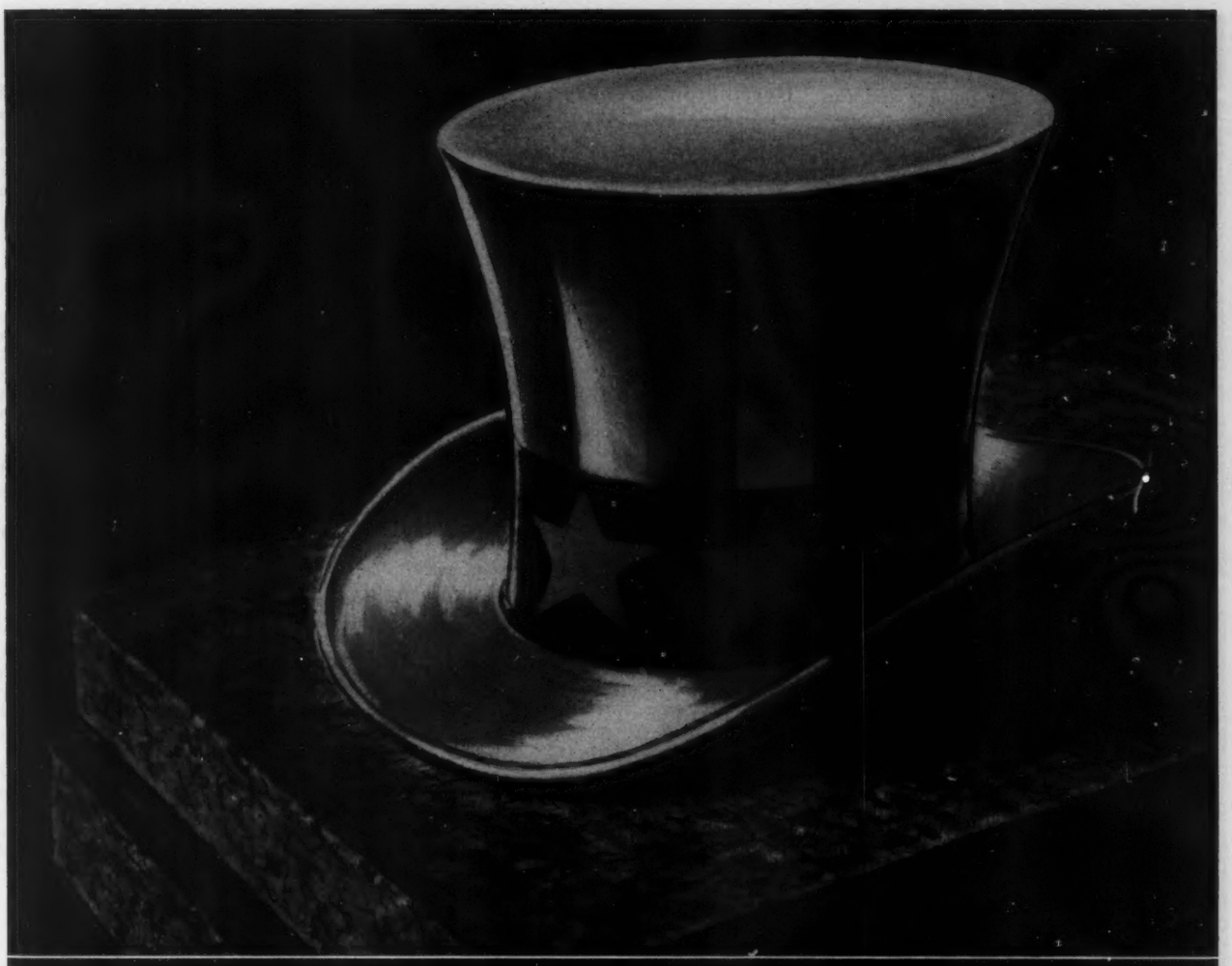


INDIVIDUAL

- Equipment designed and manufactured for individual needs of refiners.
  - THERMO WELLS
  - HEAT EXCHANGERS
  - PRESSURE FITTINGS

ENGINEERS
M.L. BAYARD & CO.
INCORPORATED
MACHINISTS

PHILADELPHIA



"...but can I get cork insulation?"

THAT'S the question which has been asked by many hundreds of insulation users since last June, when cork was put on the government's mandatory priorities list. It is not surprising that there are questions as to how much corkboard and cork covering is available and who *can* get it.

Most users know that cork must be imported from Portugal, Spain, or Algeria. They realize that shipping is severely restricted . . . that normal peace-time imports are out of the question. Some users even think that, because of these restrictions, little or no cork insulation is available for *any* purpose.

HERE IS THE SITUATION

Armstrong's Corkboard and Cork Covering are available for uses where they aid defense. Included in this category are direct defense uses such as insulation for Naval craft, powder plants, and refrigerated storages at Army camps and Navy bases. Of comparable importance are chemical plants and other vital producers. Plants making synthetic rubber and oil refineries for example can also get this efficient insulation.

After direct defense needs are met, the remainder from supplies allocated monthly is available chiefly for food preservation. In recent months many meat packers, dairy operators, and others in the perishable foods field have been getting the efficient, dependable insulation they needed . . . Armstrong's Corkboard and Cork Covering.

If you're planning new insulated construction get in touch with your Armstrong Cork man. The information he gives you will be authentic. His suggestions will be helpful. And Armstrong's engineers will be glad to go over your plans and offer their suggestions which may avoid delays and expense later on.

So don't guess about your insulation needs. Call the nearest Armstrong office or distributor now and get the information you want about deliveries of corkboard and cork covering. Or write direct to Armstrong Cork Co., Building Materials Div.,1001 Concord St., Lancaster, Pa.

ARMSTRONG CORK COMPANY
Insulation Headquarters

CORKBOARD ★ CORK COVERING ★ FIBERGLAS* ★ TEMLOK ★ INSULATING FIRE BRICK
*Reg. U. S. Pat. Off. O.-C. F. Corp.

taken from the right hand side of the pointer to the zero line.

Where the lines are not calibrated a rule is placed with the end against the right hand side of the pointer and the measurement is read at the zero line.

Cutting Tip

AIR REDUCTION SALES COMPANY

Air Reduction Sales Company, 60 East Forty-second street, New York, has designed a series of oxyacetylene machine cutting tips, which increases the speed of machine torches by 20 to 30 percent.

The Airco "45" high speed machine cutting tip has a nozzle with a divergent exit portion—a design that makes it possible to eject a narrow, high-velocity stream of oxygen, practically free of exit turbulence, that burns a narrower path or kerf, through the metal, than the conventional cutting tip. As a result of burning away less width of metal in a cut, the Airco "45" cuts with no increase in oxygen consumption.

To obtain a kerf of narrower width than that obtained in standard cutting practice, it is necessary to use a narrow, parallel-walled oxygen stream. This is obtained when a high operating pressure is used in a divergent tip that reduces the exit turbulence of the oxygen stream.

As the oxygen stream penetrates steel, its velocity is constantly dissipated. The divergent tip principle increases the velocity of the oxygen stream, and provides a higher oxygen concentration at greater depths, thereby increasing the oxidation rate of the metal being cut.

BUSINESS NOTES

Herrington Elected President of SAE

A. W. Herrington, president of Marmon-Herrington Company, Indianapolis, has been elected president of the Society of Automotive Engineers. His efforts will be directed toward directing the functions of the organization into the military program.

Moorlane Company Buys Braden Steel Corporation

The Moorlane Company, Tulsa, has acquired Braden Steel Corporation, Tulsa.

Braden Steel Corporation has been operated in the past few years by Colonial Trust Company of Pittsburgh. The personnel of approximately 50 employes will be retained, and the concern will continue to operate as a separate corporation, Moorer said.

Officers are William D. Moorer, president; S. D. Hunt, vice-president; H. S. Medlin, secretary-treasurer of both companies; L. T. True, assistant treasurer of Braden; James C. Pharr, assistant secretary. The deal will result in enlarged operations of the Braden firm, Moorer said.

Wyatt Adds Sound-Proof Shop Office to Dallas Plant

Wyatt Metal & Boiler Works, Houston and Dallas, has added a modern shop office to its plant at Dallas. Ceilings and walls of this new office are insulated against all shop noises, vibrations, and heat. Special offices have been included in the building for visiting inspectors or plant men. Shower baths, lavatories, and lockers are provided for all workers.

Oakite Products Adds Two Division Offices

Oakite Products, Inc., 50B Thames Street, New York, has set up two new division offices, one for the Southwestern area at St. Louis and the other at Hartford, Connecticut, for the New England area. Both were opened January 1.

S. C. Shank is the division manager at St. Louis. He has covered the midwestern area of the United States for the company since 1930.

T. R. Smith will supervise the activities of 11 men on his staff.

Seamless Steel Tube Institute Offers New Service to Users

The Seamless Steel Tube Institute, Gulf Building, Pittsburgh, has established a service whereby purchasers may obtain information as to the availability of various grades and sizes of seamless steel tubing.

This step was taken for the benefit of two classes of tube purchasers. First, are those who have bought certain grades of tubing for use in peace-time products, but may be unfamiliar with

ALL-OUT PRODUCTION DEMANDS PROVEN EQUIPMENT

NATIONAL AIROIL BURNERS HAVE STOOD THE TEST IN MOST OF OUR COUNTRY'S REFINERIES

Your proof of the high efficiency of the National Airoil Burner in aiding all-out production, is the use by so many representative refineries. It's a burner of rugged durability, practically care-free in continuous operation, and exceptionally economical.

Features of Type S. A. (shown at right): Internal mixing, steam atomizing burner, completely consuming every atom of cheapest and heaviest grades of oil and tar without clogging or need of cleaning. Operates with low oil pressures and temperatures — uses minimum of steam for pumping, heating and atomizing — holds desired flame regulation with absolute precision.

Literature describing: High and medium pressure steam atomizing oil burners. Rotary electric motor-driven mechanical oil burners. Rotary air turbine-driven mechanical oil burners, complete line of auxiliary equipment — free on request.

WRITE US AS TO YOUR OWN FUEL BURNING PROBLEMS. OUR ENGINEERS WILL GLADLY ADVISE YOU — *NO OBLIGATION, OF COURSE!*

NATIONAL AIROIL BURNER COMPANY, INCORPORATED
1254 East Sedgley Avenue
PHILADELPHIA, PENNA.

GETTING THE *MOST* FROM YOUR THERMAL INSULATIONS...

MAKE SURE THE MATERIAL
IS RIGHT FOR THE SERVICE...
NUMBER 1 in a series of messages to American industry devoted to conserving heat, improving operation and increasing production through modern insulation practice.

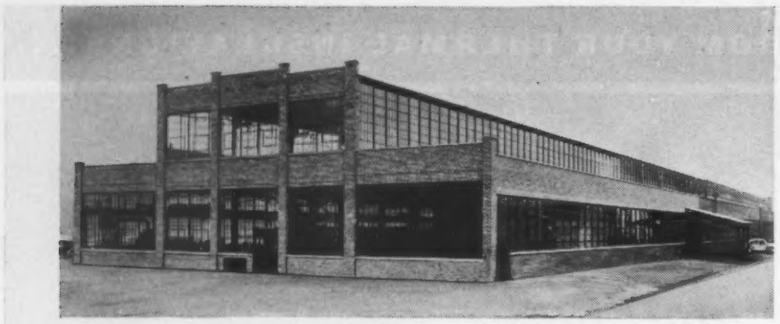
There can be no compromise in specifying the fabric for a parachute—for obvious reasons. And thermal insulations, which are industries' protection against heat loss, should be as carefully chosen for the temperatures and service conditions involved. The failure of an improperly used insulation is seldom dramatic, but always costly.

In times like these, when increases in steam pressures and process temperatures are the rule, it is sound practice to check your present insulating materials—and your insulation requirements—and to specify the proper Ehret insulation for your particular service needs.

★ EHRET'S 85% MAGNESIA and many other Ehret heat insulating materials are fully treated, both as to selection and application, in the new 176 page Heat Insulation Handbook. It will be furnished, without obligation, to those interested in getting the most from their thermal insulations. Write today for your copy of Handbook F 202.

EHRET MAGNESIA MANUFACTURING CO.
VALLEY FORGE, PENNA.

...THERE IS AN *EHRET* DISTRIBUTOR OR CONTRACTOR IN EVERY INDUSTRIAL AREA



Clark Brothers Company has completed a new plant addition to take care of the manufacture of large triple expansion marine steam engines, as part of the military program. The new engines are 2500 horsepower, largest the company has built.

Wanted

BY DESIGNERS AND BUILDERS

of

PROCESS INDUSTRY PLANTS

for

HIGHLY IMPORTANT

DEFENSE WORK

★

WANTS

PIPING DESIGNERS AND DRAFTSMEN

Experienced in the layout and detailing of piping for oil refinery units, processing plants, or chemical plants.

STRUCTURAL DESIGNERS AND DRAFTSMEN

Experienced in design and detailing of steel structures, foundation and concrete work, and industrial buildings.

PROCESS EQUIPMENT DESIGNERS AND DRAFTSMEN

Experienced in design of pressure vessels, fractionating columns, heat transfer equipment, and the like.

ELECTRICAL ENGINEERS

Experienced in electrical layout for process plants. Must know explosion-proof work.

INSTRUMENT ENGINEERS

Experienced in instrumentation and control of process plants.

SPECIFICATION WRITERS

Experienced in preparation of specifications for purchase and preparation of bills of material for process plant construction work.

Excellent opportunities for the right men. Write, outlining qualifications and experience. Personal interviews will be arranged when desirable.

Blaw-Knox Company

PROCESS INDUSTRIES DEPT.

PITTSBURGH, PA.

sources of supply for other or special grades of tubing required for war equipment. Second, and perhaps more frequently encountered today, are those manufacturers who never before needed seamless steel tubing. This is particularly true in the case of certain specialties which are not manufactured generally, and may be available only from two or three mills. Some mills confine their output to carbon steel tubing exclusively, others specialize to a greater or lesser extent in the production of tubing of various alloys such as the stainless analyses and many of the SAE grades.

Babb Chairman, Buchanan President of Allis-Chalmers

Max W. Babb, president of Allis-Chalmers Manufacturing Company, Milwaukee, has been elected chairman of the board of directors, and W. C. Buchanan, a director and member of the executive committee, has been elected to succeed him as president. Buchanan has for the past six years devoted a substantial portion of his time to Globe Steel Tubes Company, in Milwaukee, of which he is president, and in which capacity he will continue.

Max W. Babb

Babb, in becoming chairman of the board will fill the position formerly occupied by the late Otto H. Falk, which has been vacant since his death in 1940.

These changes in management were made in order further to improve the company's position, with particular reference to production, as heavy and increasing demands are being made on its facilities in connection with the nation's war work, it was said.

Mathieson Celebrating Fiftieth Anniversary

Mathieson Alkali Works, Inc., manufacturer of caustic soda, soda ash, and other chemicals used in petroleum refining, is observing its fiftieth anniversary. The company was incorporated in Virginia in 1892.

With plants in Saltville, Virginia, Niagara Falls, New York, and Lake Charles, Louisiana, Mathieson is one of the major producers of alkalies, chlorine, synthetic ammonia, and numerous other products. At present, all three

GASKETS

"MELRATH"

"MELOIL"

"MELBESTO"

● **We make gaskets in steel, copper, lead, monel metal stainless steel, Armco iron, aluminum, nickel, fibre, rawhide, rubber or any other material. Plain, corrugated or perforated metal. Metal-asbestos and other combinations; to suit any use—for gasoline, acids, oil, chemicals, alcohols, steam, ammonia, etc. Any size, shape, quantity.**

MELRATH

SUPPLY & GASKET CO., INC.

Tioga & Memphis Sts., Phila., Pa. Est. 1909

FOR SALE

OIL STORAGE TANKS

3—55,000 Bbl.
1—25,000 Bbl.
5—10,000 Bbl.
3— 5,000 Bbl.
4— 2,500 Bbl.
1— 1,000 Bbl.
2— 750 Bbl.
2— 600 Bbl.
2— 1,200 Bbl. Agitators

Can be inspected at Middlesex Refinery Company, Raritan, N. J.

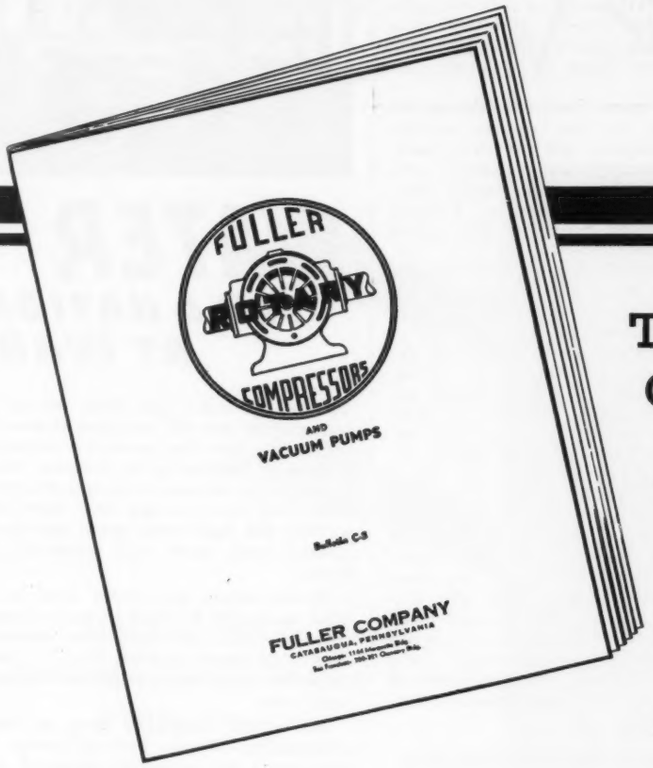
Address your inquiries to

Dulien Steel Prod., Inc.

2280 WOOLWORTH BLDG.
NEW YORK CITY, N. Y.
TELE. CORT. 7-4676

FULLER ROTARY COMPRESSORS AND VACUUM PUMPS

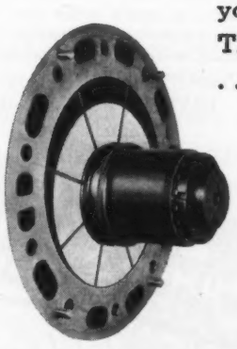
ARE DESCRIBED
IN THIS NEW BULLETIN



THIS BULLETIN JUST OFF THE PRESS . . .

OF SPECIAL INTEREST TO SUPERINTENDENTS AND MAINTENANCE MEN LOOKING FOR LOW-COST OPERATION.

If you are interested in compressed air or gases, capacities to 1800 c.f.m. actual free-air delivery, pressures to 125-lb. —vacuums to 29.90 in., (referred to 30 in. barometer), you should investigate these highly efficient machines. This new bulletin illustrates and describes these units . . . send for your copy today . . . just fill in the coupon.



FULLER COMPANY
Catasauqua, Pa.

Please send me a copy of Bulletin C-5.

Name.....

Company.....Title.....

Address.....

City.....State .....

C-65

FULLER COMPANY
CATASAUQUA—PENNSYLVANIA
CHICAGO—Marquette Bldg. SAN FRANCISCO—Chancery Bldg.

For Example:

HEAT EXCHANGERS NOW CLEANED EASIER, FASTER!

To meet war demands for gasoline, oil and other petroleum products, producing and refining equipment must operate at peak efficiency. Equally important, required maintenance must be handled on a fast, easy, low-cost basis.

That is why we say . . . clean your heat exchangers FASTER and EASIER and keep "thumbs down" on maintenance costs . . . by doing this important job the simple, successful Oakite way! No dismantling required. Just circulate recommended Oakite solution through units as directed . . . and you will find insulating lime-scale, carbonized oil or sludge deposits thoroughly removed. Normal heat transfer is restored, output increased. Units are back in service quickly.

Save Time . . . Money ON THESE JOBS, TOO!

Let Oakite materials help you establish economies on such other jobs as cleaning flame arresters, absorption towers, tank car interiors. Write for data.

OAKITE PRODUCTS, INC.
50B THAMES STREET, NEW YORK, N. Y.
Representatives in All Principal Cities of the United States and Canada

OAKITE CERTIFIED CLEANING
MATERIALS . . METHODS . . SERVICE

plants have been geared to maximum production to supply chemicals vitally necessary to our all-out war effort.

Half a century ago, all of the bleaching powder and most of the alkali consumed in this country were still imported from England, and the prejudice in favor of the imported products was strong. To insure a product equally as good, construction and initial operation of the new company's plant were entrusted to a retired English alkali manufacturer, Neil Mathieson. He sent a son, Thomas T. Mathieson, to this country, and under the latter's supervision a plant was built at Saltville, Virginia, where there are huge and historic salt deposits.

About that same time, Mathieson obtained control, in this country, of the Castner electrolytic cell for the manufacture of extremely pure caustic soda and chlorine, and to obtain cheap power, a plant was constructed at Niagara Falls. Production began in this plant late in 1896.

Other Mathieson accomplishments include the commercial production of synthetic ammonia in 1923; the development of a true calcium hypochlorite as a new chlorine carrier in 1928; the development of sodium chlorite as an improved bleaching agent for textiles, paper, flour, and other materials in 1939; fused alkalies in briquet form for a variety of uses; synthetic salt cake to replace foreign supplies for kraft paper manufacturers; exceptionally pure dry ice and carbonic gas from carbon dioxide, obtained as a by-product from the ammonia soda process at Saltville; especially designed containers for the shipment of liquid chlorine; and the distribution of caustic soda in liquid form in tank cars and in a specially designed sea-going tanker, plying between Lake Charles and Norfolk, Virginia, where Mathieson operates a liquid caustic storage terminal.

Dresser Manufacturing Company Acquires Additional Facilities

Dresser Manufacturing Company, Bradford, Pennsylvania, has acquired Bovaird and Seyfang Manufacturing, also of Bradford, as a wholly-owned subsidiary. The plant will serve during the military emergency as extra manufacturing capacity for Clark Bros. Company, Olean, New York, also a Dresser subsidiary. The new plant has space of 147,000 square feet and shop equipment includes heavy machine tools, a boiler shop, grey iron foundry.

Fluor Corporation Makes Two Additions to Plant

Fluor Corporation, Ltd., has announced two additions to its plant at 2500 South Atlantic Boulevard, Los Angeles. A new research and development laboratory will be provided and another wing added to the office for the engineering department. The added wing is the third for the structure and the second for the engineering department since the office building was completed in September, 1940.

The research and development laboratory is in keeping with a program to round out the scope of the company in its service to the oil and gas industry. Facilities will be provided for the study and behavior of gases under high pressure and for the study of the complex problems in modern refining processes, particularly those of isomerization and

WATER FOR A NATION AT WAR!

To the East and to the West, we are looking straight into the cannons of war. From within we face the inevitable saboteur. It is time to become grim, cautious and determined in our war aims and actions. We must win this war and do a good job of it. We will fight with men, metals, fuel, power, food, water and materials of all kinds.

Never before has water been a more vital necessity. Beyond its task of serving men, materials and machines, water now also must guard against fire . . . protect factories, equipment, supplies, homes . . . and lives.

As in the strenuous days of defense preparation, Layne now is ready, fully equipped and speedily engaged in an even greater task . . . that of providing water for a Nation at war. This activity includes service to the Military and Naval forces, essential industries and necessary repair work.

Check your water supply and install necessary wells and pumps. See that all present wells and mechanical equipment are placed in good order and kept ready for any emergency. Repairs to existing equipment will conserve material needed for war purposes.

LAYNE & BOWLER, INC.
Memphis, Tenn.

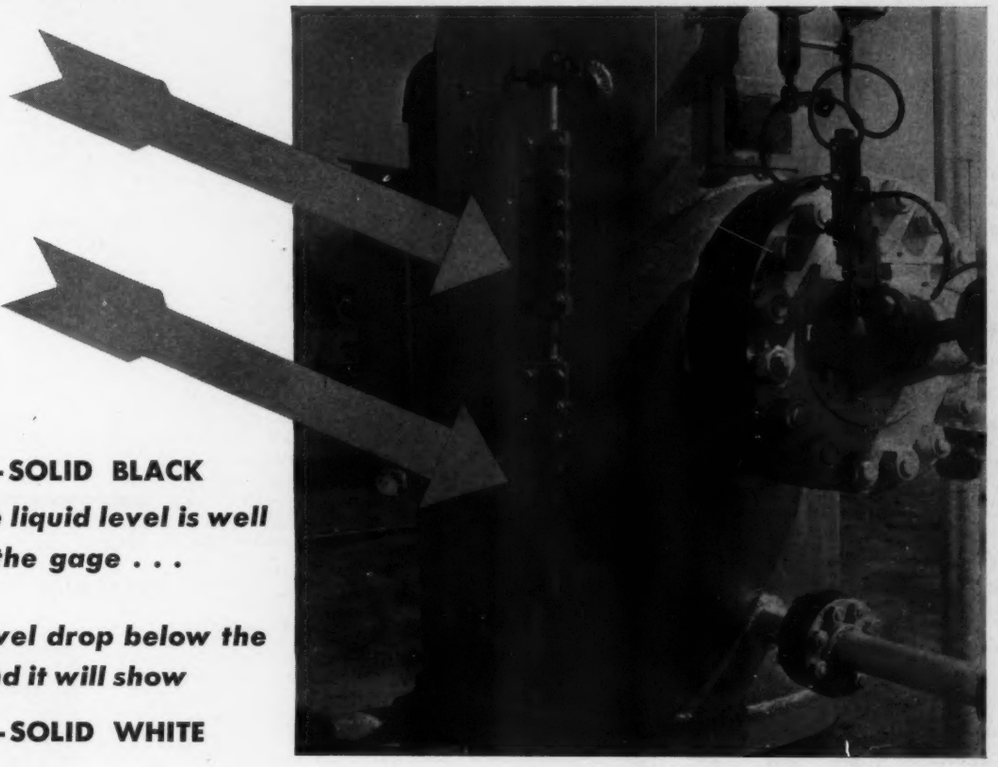
LAYNE PUMPS & WELL WATER SYSTEMS
Affiliated Companies

Layne-Arkansas Company	Stuttgart, Ark.
Layne-Atlantic Company	Norfolk, Va.
Layne-Central Co.	Memphis, Tenn.
Layne-Northern Company	Mishawaka, Ind.
Layne-Louisiana Company	Lake Charles, La.
Layne-New York Co.	New York City.
Layne-Northwest Company	Milwaukee, Wis.
Layne-Ohio Company	Columbus, Ohio
Layne-Texas Company	Houston, Texas.
Layne-Western Company	Kansas City, Mo.
Layne-Western Co. of Minn.	Minneapolis, Minn.
Layne-Bowler New England Corp.	Boston, Mass.
International Water Supply, Ltd.	London, Ont.

WORLD'S LARGEST WATER DEVELOPERS

★ JERGUSON ★

Reflex Gage of Sure Visibility



BLACK — SOLID BLACK
indicating the liquid level is well above the gage . . .

. . . let the level drop below the gage and it will show

WHITE — SOLID WHITE

THE REFLEX GAGE provides the surest visible determination of liquid levels in tanks; that is, whether the level is well above, approaching, or below a critical point. Where there is liquid, the gage shows solid black; where there is none, it's white. The Jerguson Reflex Gage, used by many refineries and other plants in the petroleum industry, is sturdily built of forged and alloy steel parts, scientifically tempered glass, and constructed with a U-bolt assembly to give added strength.

JERGUSON GAGE & VALVE CO.

87 FELLSWAY — SOMERVILLE, MASS.

Desco Corporation
2nd & Welsh Sts., Chester, Pa.

Bushnell Controls & Equipment Co.
(All of California)
117 West Ninth St., Los Angeles, Calif.

W. D. Emery Co.
1015 McBirney Building, Tulsa, Okla.

O'Brien Equipment Co.
2726 Locust Boulevard, St. Louis, Mo.

Associated Valve & Engineering Co.
510 North Dearborn St., Chicago, Ill.

H. R. Bowers
1758 Wright Ave., Cleveland, Ohio
Rocky River Branch

J. Arthur Moore
342 Madison Ave., New York, N. Y.

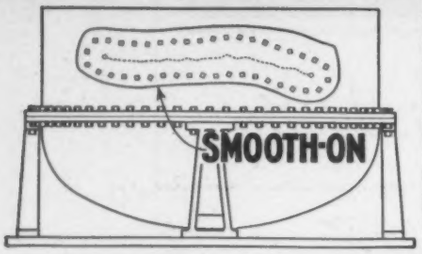
The J. A. Rossiter Co.
Houston, Texas

Murray-Baker-Frederic, Inc.
620-630 S. Peters St., New Orleans, La.

Paul B. Huyette Co., Inc.
401 North Broad St., Philadelphia, Pa.

2-JV-1

HOW SMOOTH-ON
helps to prevent production delays



A leak in a pipe line . . . a crack in a pump casing . . . a loosened bracket due to stripped threads . . . these are typical of plant operating troubles which might cause loss of valuable production time if not promptly corrected.

You *can* make repairs like these . . . without dismantling apparatus, without heat or special tools, and with lasting results . . . by using SMOOTH-ON No. 1, the iron repair cement of a thousand uses.

Whenever a crack develops in a casting, or a leak occurs in a seam or joint, or a machine part or fixture becomes loose . . . SMOOTH-ON will correct the trouble speedily and economically, frequently avoiding costly interruptions to service.

FREE

The 40-page Smooth-On Handbook—full of valuable suggestions that will save you time, effort and money on equipment repairs, such as sealing cracks in heaters, pumps, tanks, etc., stopping leaks at seams and bolts, tightening loose fixtures and parts of apparatus, waterproofing walls, floors, etc. Send the coupon for your copy.

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570 Communipaw Ave., Jersey City, N. J.

Please send copy of the SMOOTH-ON-HANDBOOK.

Name.....

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Do it with
SMOOTH-ON

alkylation. Studies of the problems related to the recovery of natural gasoline and lighter hydrocarbon fractions from field gases, gas treatment and gas cleaning will be undertaken.

The laboratory will have a concrete apron to serve as a foundation for the erection of pilot plants. There will be a steam plant to provide working pressure of 150 pounds. The laboratory and equipment will cost $25,000.

Research and development will be under the direction of A. J. L. Hutchinson, chief process engineer, Ira C. Bechtold, F. W. Bell and Ernest Moncrief.

Lincoln Electric Company Issues New Edition on Blue Prints

A new edition has been printed of "Simple Blue Print Reading with Special Reference to Welding," by The Lincoln Electric Company, Cleveland, Ohio. The volume is concisely written in simple, practical language for the purpose of giving welders and other mechanics an appreciation of print reading.

More than 50 drawings have been revised for the revised edition. It has eight pages of drawings in addition to those previously used.

Wirene Made Assistant Sales Manager by General Electric

W. A. Wirene has been appointed assitant sales manager of the petroleum, chemical, mining and steel-mill section of General Electric Company's industrial department. He has been with the company since 1925. One year later he entered the sales training course and was transferred to the industrial department. After service in district offices he returned to Schenectady in 1940 as a sales engineer of the petroleum and chemical section.

James S. Anderson Now With Babcock & Wilcox Tube Company

James S. Anderson is now with the New York district sales office of The Babcock & Wilcox Tube Company, 65 Liberty Street. Formerly he was with the steel and tubes division of Republic Steel Corporation in the Cleveland and the Philadelphia offices.

Worthington Pump Appoints Passmore Works Manager

George P. Passmore has been appointed works manager of the Wellsville plant of Worthington Pump and Machinery Corporation, Harrison, New Jersey. Until recently he was manager of manufacturing at the South Philadelphia plant of Westinghouse Electric and Manufacturing Company.

Vapor Recovery Company Adds Fifth New Factory Unit

The Vapor Recovery Systems, Compton, California, has added a new foundry to its facilities for manufacturing gas control and tanks equipment as well as safety devices. It is the fifth integral unit to be added to the plant in recent months.

Chicago Office Moved

The Chicago office of Copperweld Steel Company has been moved to 122 South Michigan avenue. R. S. Clingan is in charge of the district.

Lukens Steel Company Elects Two Directors

James F. McNamara, mill products sales manager of The International Nickel Company, has been elected a member of the board of directors of Lukens Steel Company. Another new director is Warren H. Snow, president of E. H. Rollins & Sons, Inc., New York.

Chicago Pneumatic Tool Creates New Department

J. R. Davis has been appointed supervisor of branches for Chicago Pneumatic Tool Company. The appointment followed creation of the department. He joined the company in December. He will standardize sales office procedure and coordinate sales plans and quotas with branch and division managers.

Called to Service

Harold M. Moore, St. Louis representative of Manning, Maxwell & Moore, Inc., has been called to military service.

Pipe Tools

Beaver Pipe Tools, Inc., Warren, Ohio, has compiled both its general catalog and a four-page condensed catalog.

The general catalog covers the complete line of portable pipe and bolt cutting and threading machines; portable pipe and bolt cutting and threading power drives and power units; pipe cutting and threading tools, ⅛ to 12-inch; pipe reamers; vises; sawing vises; grooving and beveling tools and threading oil. The book is completely illustrated and detailed information concerning each item in the line is given.

The 4-page condensed catalog is a handy, quick reference piece of especial interest to jobbers' salesmen.

THE ONLY HANDBOOK OF BUTANE-PROPANE GASES

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